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BATTLE CRUISER.

UNITED STATES NAVY.

Design of 1916.

MODERN SEAMANSHIP

BY

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REAR-ADMIRAL, UNITED STATES NAVY.

UNABRIDGED REPRINT

OF THE

SEVENTH EDITION

160 FULL PAGE PLATES

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PREFACE TO SEVENTH EDITION.

THE present edition of Modern Seamanship is designed to bring the work up to date as completely as possible. To this end, a large amount of new material has been added, much that was obsolete has been cut out, and about one-third of the remainder has been extensively revised or entirely rewritten.

In spite of the fact that the changes introduced have, upon the whole, added to the contents of the book, its size has been greatly reduced by changes in the weight of paper used for both text and illustrations, and it is believed that in its new form it will be found much improved in endurance and convenience of handling.

AUSTIN M. KNIGHT,
Rear Admiral, U. S. Navy.

U. S. NAVAL WAR COLLEGE,
NEWPORT, RHODE ISLAND, March 1, 1917.

PREFACE TO FIRST EDITION.

An attempt is made, in the following pages, to cover a wider field than that covered by most of the existing works on Seamanship.

The admirable treatises of Luce, Nares, and Alston, originating in the days when seamanship was almost wholly concerned with the fitting and handling of vessels under sail, have preserved through later editions the general characteristics which they naturally assumed in the beginning. These treatises will never be out of date until the time, still far in the future, when sails shall have been entirely driven out by steam. It will hardly be denied, however, that the Steamer has long since established its claim to consideration in Seamanship, and that there is room for a work in which this claim shall be more fully recognized than in the treatises above referred to. The excellent work of Captains Todd and Whall, "Practical Seamanship for the Merchant Service," deals more fully than either of its predecessors with the handling of steamers; but its point of view is, as its name implies, primarily and almost exclusively that of the Merchant Service.

Shortly after the present work was begun, a circular letter was addressed to officers of the merchant service and extensively circulated through the Branch Hydrographic Offices at New York, Philadelphia, Baltimore and Norfolk, requesting the views of the officers addressed, upon the following subjects:

I. Taking a Disabled Vessel in Tow in Bad Weather.
II. Rescuing the Crew of a Wreck in Bad Weather.
III. Rescuing a Man Overboard.
IV. Lying-to in a Gale.
V. The Stowage and Handling of Boats.
VI. Manœuvring Single-screw and Twin-screw Vessels.
VII. Floating a Stranded Vessel.
VIII. Handling Steamers around a Dock.

The answers received to these questions were unexpectedly numerous and complete. More than forty prominent officers of the Merchant Service replied, many of them writing out their views and describing their experiences with a fullness of detail far beyond anything that could have been anticipated.

The thanks of the author are due particularly to the following for letters or for personal interviews covering the above points: Capt. W. H. Thompson, S. S. Belgenland; Capt. T. Evans, S. S. Runo; Capt. J. Dann, S. S. Southwark; 1st Officer T. Anfindsen, S. S. Southwark; Capt. J. C. Jameson, S. S. St. Paul; Capt. H. E. Nickels, S. S. Friesland; Capt. G. J. Loveridge, S. S. Buffalo; Capt. F. M. Howes, S. S. Kershaw; Capt. T. J. Thorkildsen, S. S. Trojan; Capt. Otto Neilsen, S. S. Pennland; Capt. H. Doxrud, S. S. Noordland; Capt. C. O. Rockwell, Clyde S. S. Co.; Capt. S. W. Watkins, S. S. Montana; Capt. Anders Beer, S. S. Nordkyn; Capt. J. M. Johnston, S. S. Sardinian; Capt. A. R. Mills, S. S. Westernland; Capt. J. S. Garvin, S. S. Cherokee; Capt. Robt. B. Quick, S. S. El Cid; Capt. Wm. J. Roberts, S. S. New York; Capt. T. Richardson, S. S. Noranmore; Capt. E. O. Marshall, S. S. Maryland; 1st Officer H. S. Lane, S. S. Maryland; Capt. W. F. Bingham, S. S. Marengo; Capt. R. Gowing, S. S. Greatham; Capt. H. J. Byrne, U. S. A. T. McPherson; Capt. Paul Grosch, S. S. Stuttgart; Capt. Geo. Schrotter, S. S. Belgravia; Capt. F. C. Saunders, S. S. English King; Capt. Chas. Cabot, S. S. Venango; Capt. Chas. Pinkham, S. S. Queen Wilhelmina; Capt. A. Traue, S. S. München; Capt. W. Thomas, S. S. Quernmore; Capt. H. O. Nickerson, Fall River Line; Capt. Geo. Lane, Baltimore Steam Packet Co.

Important assistance was received from Naval Constructor W. J. Baxter, U. S. Navy, who prepared Chapters I and XVIII; and from Lieutenant E. E. Hayden, U. S. Navy, who contributed several Charts and much valuable information upon Meteorology, for Chapter XIX.

Chapter V was suggested by a paper, "Mechanical Appliances on board Ship," by Captain Thomas Mackenzie, issued by the London Shipmasters' Society as No. 29 of their valuable series of publications.

It would be impossible to mention all the naval officers who have assisted the author with criticism and suggestions; but acknowledgment is especially due to Lieut.-Commander A. W. Grant, Lieut. John Hood, Lieut. W. R. M. Field, Lieut. John Gow, Lieut.-Commander W. F. Worthington, Commander J. E. Pillsbury, Lieut. V. S. Nelson, Lieut. Ridgely Hunt, and Chief Boatswain W. L. Hill, all of the United States Navy.

Above all, acknowledgment is due to Chief Boatswain C. F. Pierce, U. S. Navy, who not only assisted in the preparation of many parts of the text, but prepared sketches for fully one-half the illustrations of the volume.

AUSTIN M. KNIGHT.

UNITED STATES NAVAL ACADEMY,
APRIL 1, 1901.

PREFACE TO FIFTH EDITION.

In the present edition about one-half of the material retained from earlier editions has been entirely re-written and a large part of the remainder extensively revised.

The following chapters are entirely new:

Chapter XIX. Handling Torpedo Vessels and Submarines.
Chapter XX. Keeping Station and Manœuvring in Squadron.
Chapter XXV. Hints for Junior Officers.

The revision of Chapter XII, "The Rules of the Road," has been so extensive that it is practically new. Especial attention is invited to this chapter.

Chapter XIX was prepared by two groups of officers of the United States Navy, of wide experience in the handling of torpedo vessels and submarines.

Chapter XXV, by Lieutenant B. B. Wygant, U. S. Navy, is reproduced by permission of the author and the publishers from a pamphlet published by the United States Naval Institute.

All of the chapters in previous editions which dealt with sailing-vessels have been omitted; but a brief description of such vessels is included in the Appendix, it being considered that some acquaintance with matters of this kind is desirable, if not essential, as a part of the education of a naval officer.

The Appendix includes also a considerable variety of information on other subjects of professional interest.

Plates **149**, **156**, **157**, and **158** (in Appendix), illustrating "Sailing Craft" and "Buoyage," are from the very valuable work on "Seamanship," by Commander Wilfrid Henderson, R. N., published by Simpkin Marshall, London, permission to use this material having very kindly been granted by the author and publisher.

Among the many officers of the United States Navy whose contributions or suggestions have been of importance in the preparation of the present edition, especial acknowledgment is due to Commander C. B. Brittain, Commander L. H. Chandler, Commander B. F. Hutchison, Commander C. F. Hughes, Lieutenant-Commander John Halligan, Jr., Naval Constructor R. H. Robinson, Lieutenant B. B. Wygant, Lieutenant D. C. Bingham, Lieutenant W. G. Diman, Ensign A. H. Miles, and Chief Boatswain J. P. O'Neil.

AUSTIN M. KNIGHT.

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CHAPTER I.

THE HULL AND FITTINGS OF A SHIP.

The size, form, speed, power, armor, armament and rig of a ship depend upon the nature of the services she is expected to perform. Whatever her design may be, she must have ample stability, strength, habitability, and a complete outfit of all appliances, fixed and portable, necessary to ensure her efficiency under all service conditions.

The principal types of ships are:

Battleships. Ships of the maximum offensive and defensive qualities, usually having displacements greater than ten thousand tons, great beam in proportion to length, moderate speed and power, heavy armor at water-line and on turrets with lighter armor elsewhere, heavy guns mounted in turrets or barbettes, lighter guns in broadside, and small guns mounted wherever space will permit; and one or two military masts.

All recent battleships—those designed since 1906—are of the **Dreadnaught** type, the essential characteristic of which is that, except for small calibre guns designed for defense against torpedo-craft, it carries only guns of large calibre and carries all these behind heavy armor. The type takes its name from the British Battleship "Dreadnaught" designed in 1906. This ship marked a new development in naval warfare and to a large extent rendered all earlier battleships obsolete although many of these are still, of necessity, utilized on the fighting line.

Battle Cruisers. These resemble the battleship in size and armament, but have lighter armor and much higher speed, the gain in speed being purchased by a sacrifice in weight of armor. They are, in short, very fast and very lightly armored Dreadnaughts.

Armored cruisers, having displacements greater than eight thousand tons, high speed, great power, moderate armor on turrets and barbettes, light armor at and above the water-line, a protective deck, large coal capacity, numerous guns, and one or more military masts.

Protected cruisers, having displacements greater than three thousand tons, good speed, no armor except on turrets, barbettes, or sponsons, a protective deck, varying coal capacity, numerous guns, and one or more military masts, or masts fitted for carrying steadying sails.

The use of the older forms of military masts is gradually disappearing in the newest designs, though the existing types of various navies generally include them as above stated; and the latest ships have special forms of elevated tops such as the American basket mast and the English tripod mast.

Scout cruisers, having moderate protection and armament, large coal capacity and, above all else, high speed.

Gunboats, having displacements less than two thousand tons, fair speed, good coal capacity, no armor or protective deck, moderate battery, and generally provided with moderate sail power.

Torpedo boats and destroyers, having displacements between one hundred and one thousand tons, extremely high speed, fair coal capacity, no armor, very fragile hull, with one or two signal poles. Carrying torpedoes and the necessary apparatus for launching them.

Monitors, with one or two heavily armored turrets carrying high-powered guns, very low freeboard with heavily armored sides, an armored deck, poor coal capacity, and low speed.

Submarines, of displacements up to two thousand tons. Carrying torpedo tubes and a few light guns. Designed to operate on the surface or submerged. Fitted with periscopes giving a view of the horizon when submerged. The radius of action may be as much as seven thousand miles and the maximum surface speed twenty knots or more.

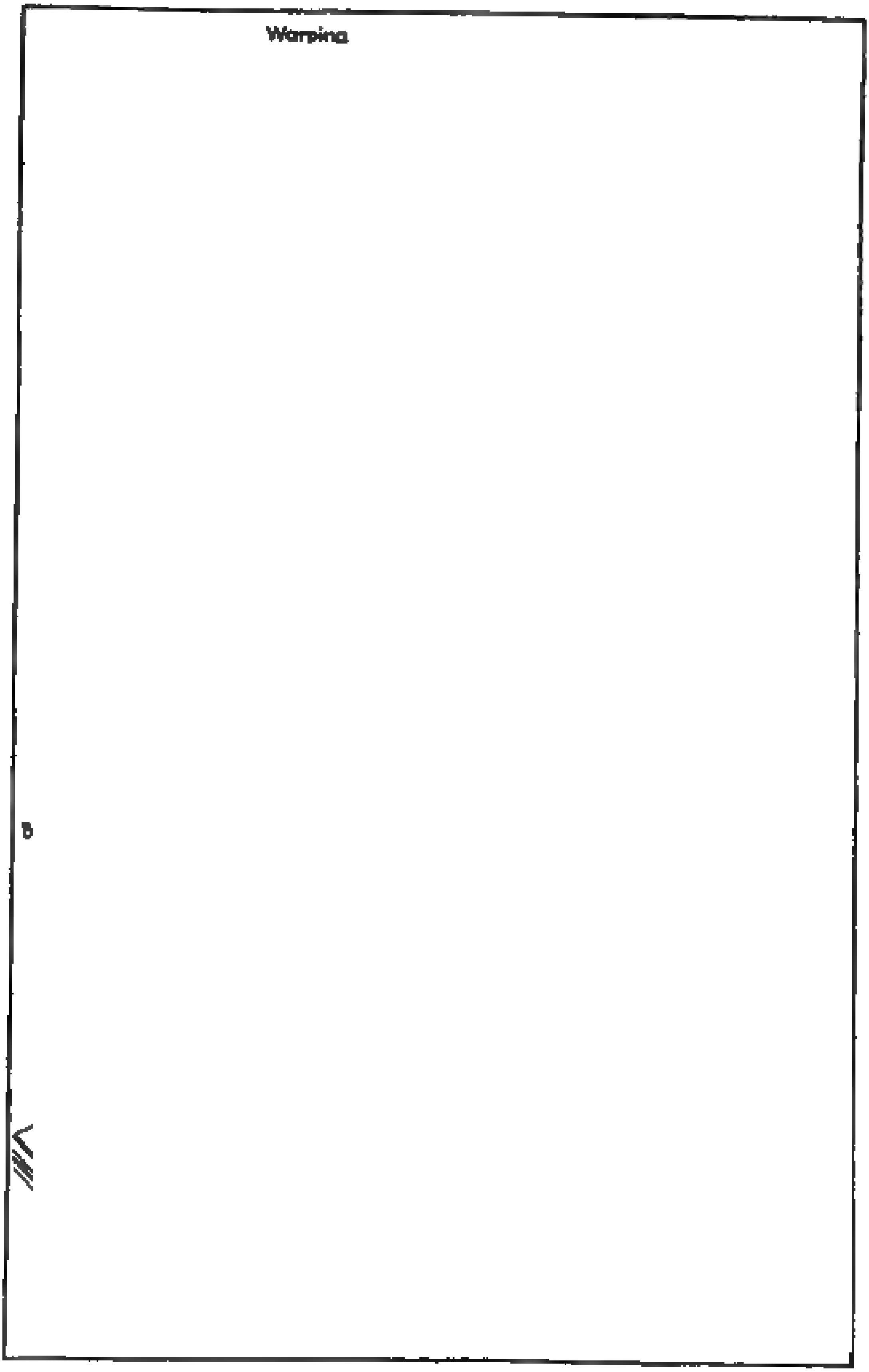
Auxiliaries. These are of many kinds, used for many purposes, as auxiliary to the fighting forces. Thus we have Fuel Ships, Supply Ships, Ammunition Ships, Repair Ships, Hospital Ships, Mine-laying and Mine-sweeping Ships, Transports, and Tenders to Destroyers and Submarines. In general, these ships are of special design and special build, but in some cases ships built for commercial purposes are utilized with such alterations as may be demanded by the purpose for which they are required.

Merchant ships, for passenger or freight service, of all sizes and speeds, no armor or protective deck, large coal capacity,

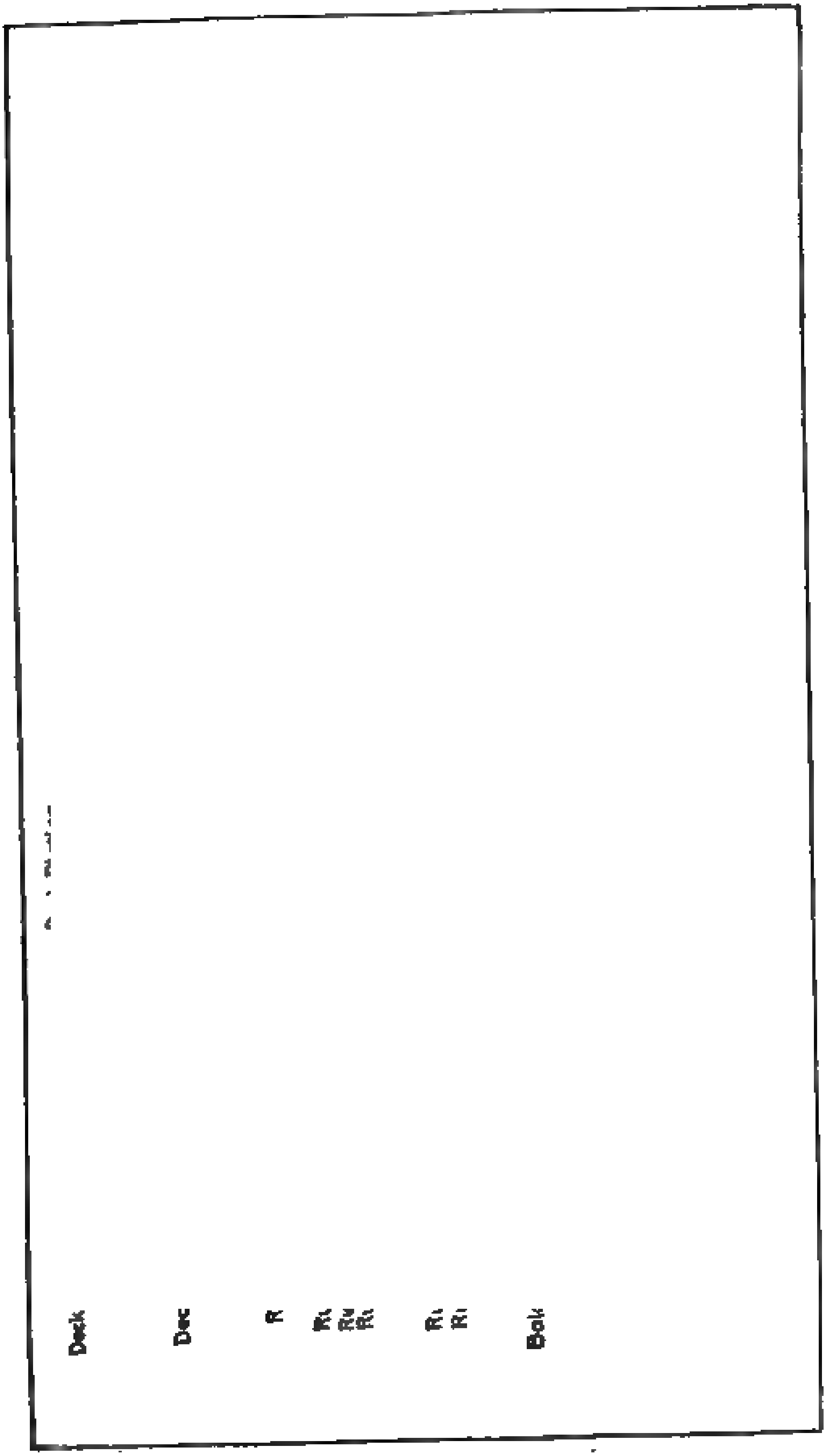
Plate No. 1.

Midship Section of a Battleship

Plate No. 2.

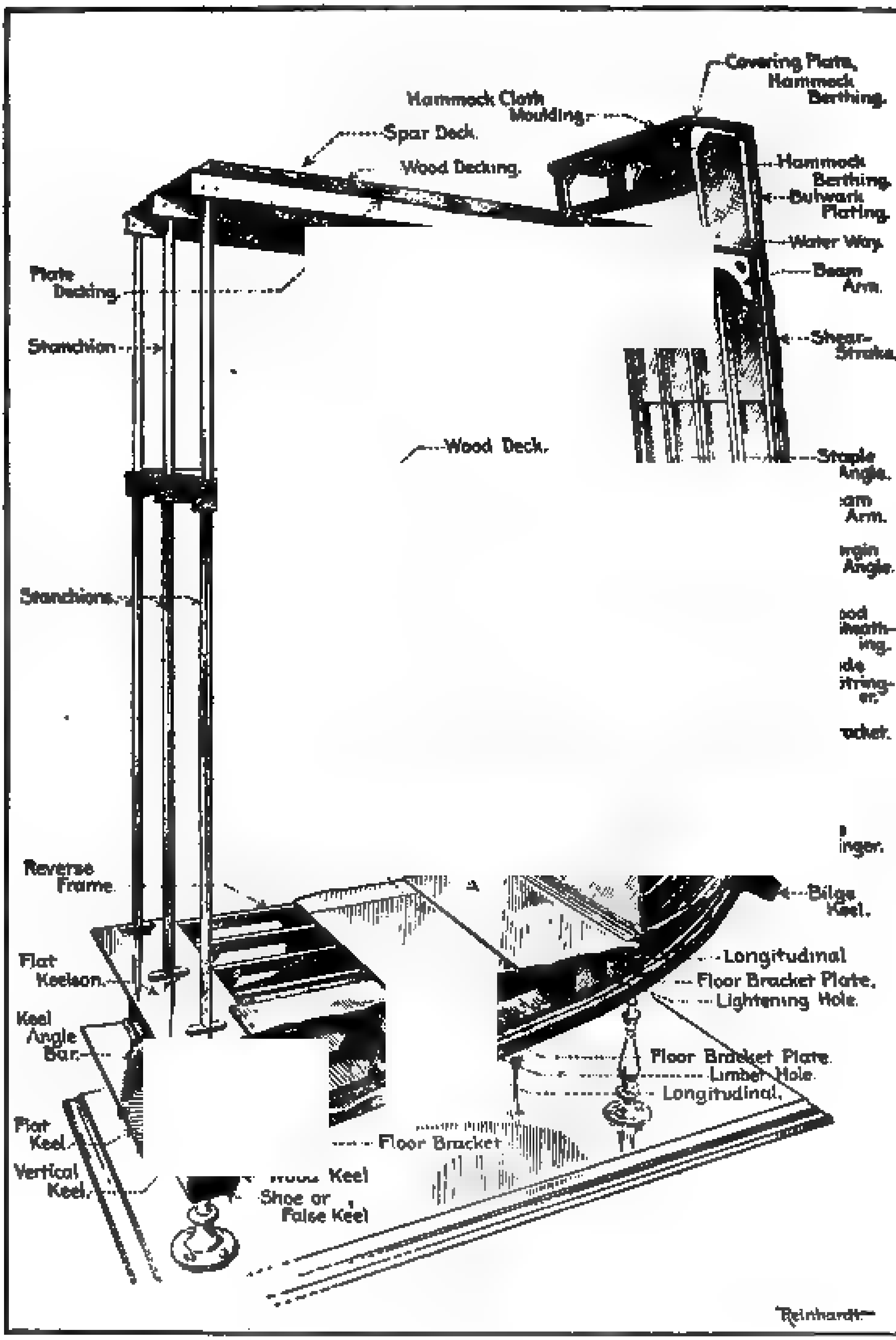


BOW OF A BATTLESHIP.



STERN OF A BATTLESHIP.

Plate No. 4.



MIDSHIP SECTION OF
1200-TON GUNBOAT (SHEATHED.)

masts for steadying sail or cargo booms, and usually provided with large double bottoms for carrying water ballast when it is needed.

Sailing ships, of wood or steel, used for training or trading purposes, with numerous varieties of rig and many special fittings adapted to the particular service on which they are engaged.

THE HULL: The principal parts of the hull of a modern ship are named below, and the locations of many of them are shown on Plates **1, 2** and **3.** These are views of the midship section, bow and stern, of a steel battleship.

The keel is usually composed of the *outer* and *inner keel plates,* the *vertical keel* and the *main keelson,* with their accompanying *angle bars.* In some merchantmen a vertical *outside keel* is fitted; and on composite and sheathed ships the keel plates carry *wooden keels* and *false keels.* At its forward end the keel is continued by the *stem,* which is of great strength, and at its after end by the *stern-post,* also very strong and arranged to carry the propellers and rudder.

To the keel are attached the *frames,* built up of *main bars, floor plates* and *reverse bars,* all of which are strengthened and stiffened by *longitudinals* of various types. To these, the *outside plating* is secured, the *garboard strakes* being adjacent to the keel plates. An *inner bottom* is fitted on large ships; this extends to the *armor shelf* on battleships and monitors, and to the *shelf plates* on other vessels. The *double bottom* extends fore and aft to a greater or less degree from the midship section, depending upon the particular type of ship; it is subdivided into small cells by water-tight frames and longitudinals, so that leakage shall be reduced to a minimum if the ship touches bottom. The frames near bow and stern are spaced more closely than elsewhere to provide local strength, and *breast hooks, ram plates, transoms,* and *counters* are fitted for like reasons.

Sheathed ships are fitted with outside plating to which is fastened outside wood planking below the water-line; **composite ships** have no outside plating but have wood planking which is fastened to the frames; in both cases this planking is coppered to lessen fouling, great precautions being taken to prevent injury to the steel hull from galvanic action.

Bulkheads are used to vertically subdivide the ship's interior into *water-tight compartments* for the preservation of buoyancy

and stability; non-water-tight bulkheads are also fitted to provide stowage and living spaces.

Decks are primarily used to provide shelter, working spaces and living quarters; secondarily, to horizontally subdivide the hull into a still greater number of water-tight compartments. Those used for the latter purpose are of steel, and may or may not be covered with planking or linoleum. Other decks are planked and calked only, but *deck stringers* and *tie plates* are used to stiffen the deck beams, which are also supported by *stanchions* in addition to the bulkheads. All of these are absolutely necessary to ensure the ship's structural strength. To secure accessibility to all parts of the ship, numerous *hatches, doors, scuttles* and *man-holes* are provided; these are water-tight where necessary, and are always fitted for battening down on upper decks.

Warships are provided with *protective decks* of steel, to protect the propelling machinery and other objects below the water-line; even on gunboats it is not uncommon to find a steel water-tight deck, which assists in preventing loss of stability if the outside plating should be penetrated near the water-line.

STEERING GEAR: The *rudder* of a warship is unusually large and the steering gear unusually strong, in order that such a vessel may be under more perfect control than is considered necessary in merchantmen; and in the later designs of warships the after *deadwood* is cut away and the rudder partially balanced to still further increase the manœuvring qualities. The rudder is arranged so that it can be unshipped in dry dock. The rudder stock is made of special forged steel, its size depending upon the speed and size of the ship and the rapidity with which it is necessary to put the helm hard over when the ship is at her maximum speed. The rudder frame is usually of cast steel, which is filled in with wood and covered with steel plating. On most ships, the weight of the rudder is taken on a suitable carrier within the ship, firmly supported by the hull structure and so arranged that the stuffing box and gland attached to the rudder-post casting may be accessible, as shown on Plate **5**. With sheathed or composite ships, copper alloys are used instead of steel for rudder post and rudder.

To the rudder head, the rudder cross-head or the *tiller* is firmly secured. Sometimes both are fitted, as shown on Plate **6**.

Plate No. 5.

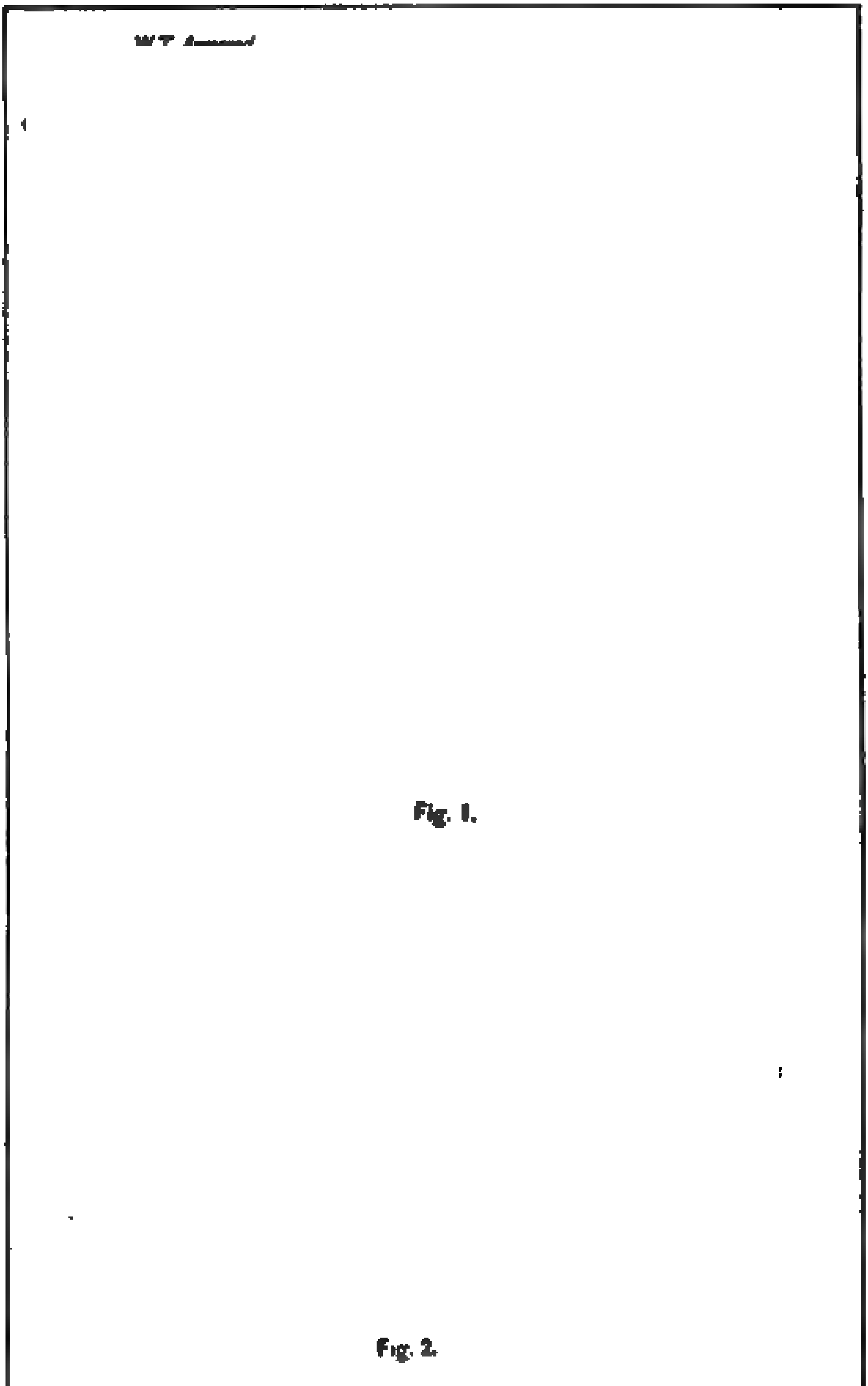
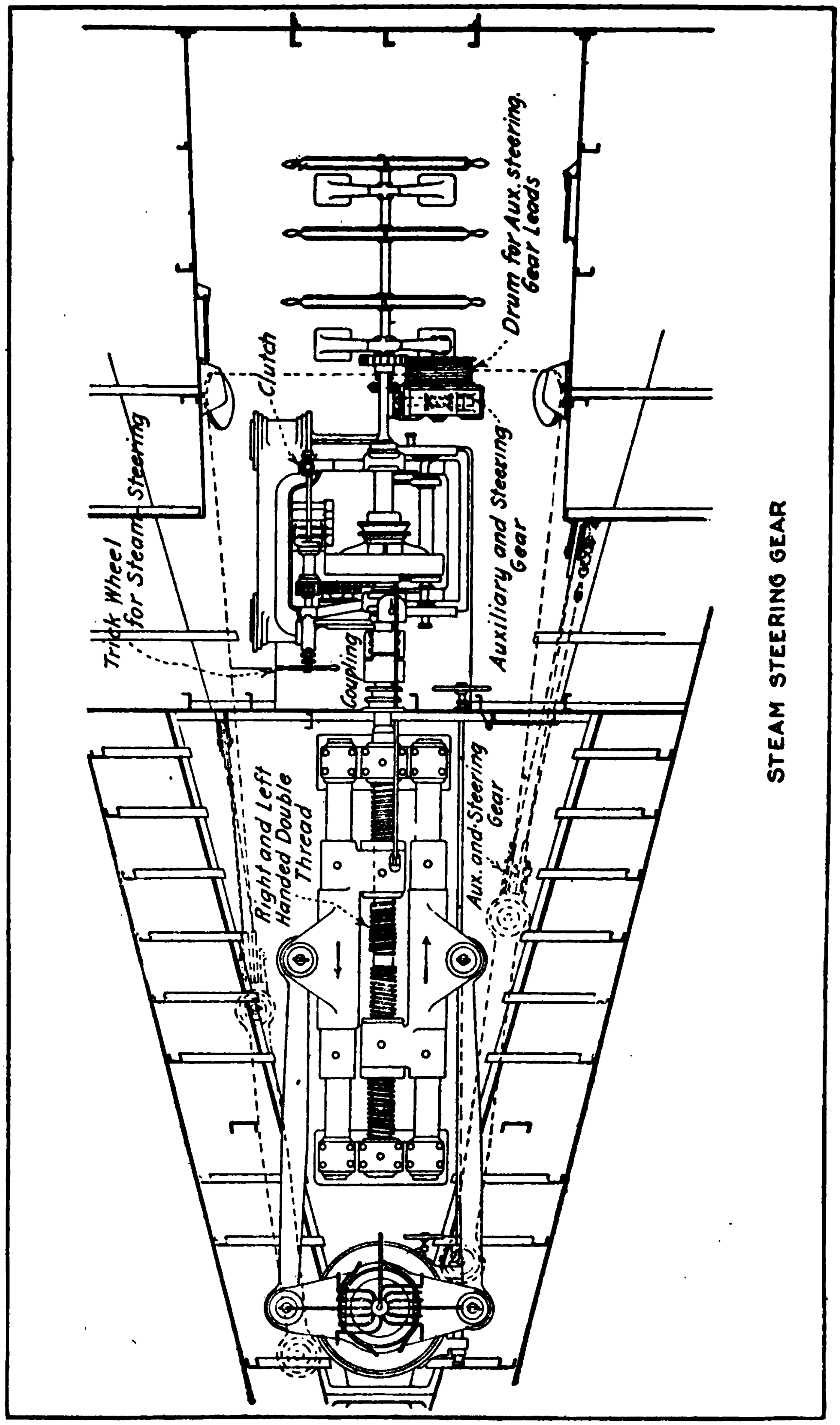


Fig. 1.

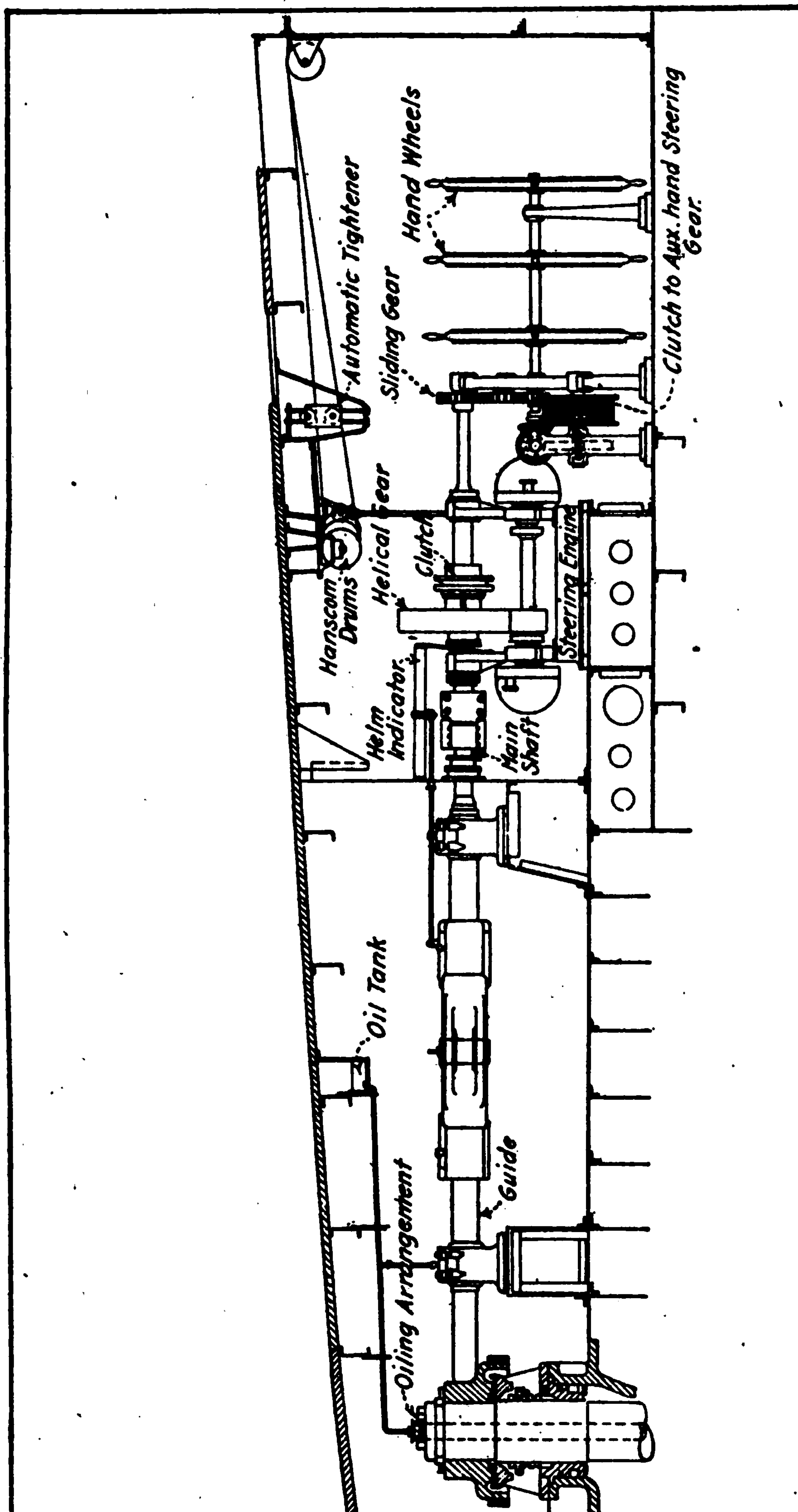
Fig. 2.

SECTIONS THROUGH RUDDER STOCK.

Plate No. 6.



STEAM STEERING GEAR



STEAM STEERING GEAR

Plate No. 8.

HAND STEERING GEAR IN CHART HOUSE
AND
CONNING TOWER OF A CRUISER

Plate No. 9.

Steering Gear Clutches

It frequently occurs that the run of the ship is so fine that it is necessary to fit a secondary cross-head placed further forward, in order to provide space for the steering gear and its connections, the two cross-heads being connected by suitable rods. It is not uncommon, where space permits, to use a straight tiller or quadrant which is connected to the steering mechanism by chain or wire rope. The rudder is thus turned through an angle of about 35 degrees on each side of the centre line, hard-over stops being fitted to the rudder post and the rudder frame to limit the amount of travel should accidents occur to the steering mechanism. The motive power is usually steam, hydraulic or electric, hand power being always provided for use in cases of complete breakdown.

Where a rudder cross-head is used (Plate 6), the engine turns a shaft having a right and left-handed thread which drives two nuts connected to the cross-head by side rods. By turning the engine in one direction the nuts recede from each other and the cross-head turns in one direction, and by turning the engine in the reverse direction, the nuts approach each other and the cross-head is turned in the reverse direction. When hydraulic power is used, the side rod from each side of the cross-head connects with a suitably guided piston rod, having a piston within a cylinder, each end of which permits the entrance of water at high pressure, and also its exhaust. By admitting water at the forward end of one cylinder and the after end of the other while at the same time opening the exhausts at the opposite ends, the cross-head is turned in one direction, and will be turned in the opposite direction by reversing the operation.

With quadrants and tillers, the chain or wire rope is wound around a drum which can be turned in either direction, suitable provisions being made to prevent any slack occurring.

The hand gear consists of steering wheels of large size located in various parts of the ship, which by shafting, chain, or wire-rope, operate the rudder in the manner shown on the plans.

Arrangements are provided for shifting quickly from power to hand gear, and from hand to power (Plate 9).

Power steering wheels are usually provided (Plate 8) in the conning-tower, in the "Central Station," and on the bridge; and where practicable are arranged with clutches so that any one wheel can be turned without turning the others. From the conning-tower stand, a steel rod extends downwards through the armored tube and below the protective deck, where it rotates

a transmission drum, which in turn rotates a second drum located in the steering room, the two being connected by the steering rope. The valve controlling the admission and exhaust of steam or water is automatically operated by the transmission drum so that the rudder is turned whenever the helmsman turns the power steering wheel, and remains stationary at any angle when the wheel is kept stationary at the corresponding position, the helm indicator showing at each instant the actual position of the helm. Various electric and hydraulic appliances are also used to accomplish these same purposes.

The application of electricity has passed beyond the experimental stage, and in recent ships the steam steering engine is replaced by an electric motor. In the very latest dreadnaughts, the power used for steering is electro-hydraulic.

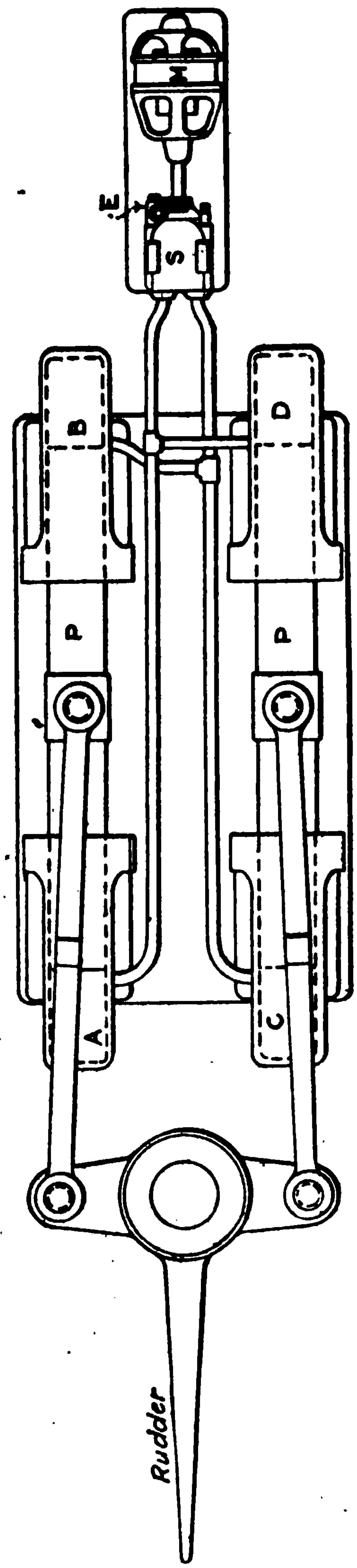
ELECTRO-HYDRAULIC STEERING GEAR.

The electro-hydraulic steering gear which is being installed on the latest vessels consists essentially of a hydraulic steering gear of the usual type which takes its supply of operating fluid from a variable stroke pump connected to a continuously running electric motor, instead of taking its supply from a constant pressure source, such as the ship's hydraulic mains or an accumulator supplied by steam pumps.

Plate **10** shows the principles of operation. Two hydraulic plungers P and P′ have connecting rods to the rudder cross-head and operate in double opposed hydraulic cylinders A, B, C, and D. The cylinders are connected by piping to a variable stroke pump, S, operated by a continuously running electric motor M. It is seen that if the operating fluid (oil) is pumped out of cylinders A and D and into cylinders B and C the rudder will be moved to starboard; and correspondingly if pumped from cylinders B and C into A and D the rudder will move to port.

The pump S, is the pump end of a Waterbury Hydraulic Speed Gear, which has been used on all late vessels for turret turning and gun elevating. The amount of oil pumped and the direction of its flow is controlled by a control shaft E. When the control shaft is in its neutral position no fluid is pumped, when it is turned in either direction from neutral the flow is in a corresponding direction, and the amount of oil pumped is proportional to the amount the control shaft is moved from neutral. Thus the control shaft performs all the functions of

Plate No. 10.



DIAGRAMMATIC PLAN OF MAIN STEERING GEAR
U.S.S. NEW MEXICO

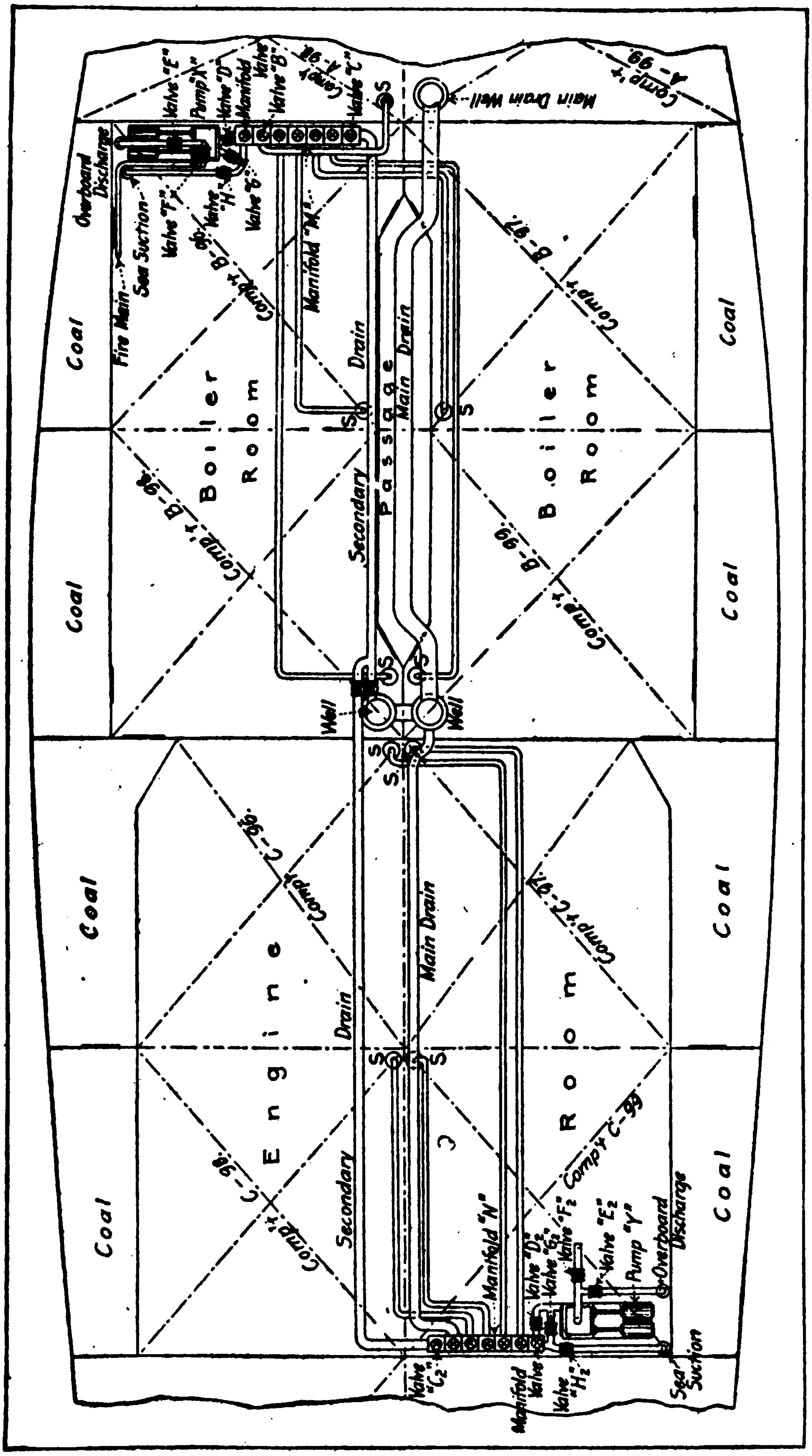
the reversing valve ordinarily used on hydraulic steering gears, and by turning it the rudder is moved. The speed of the rudder is proportional to the amount the control shaft is moved from its neutral position, and when the control shaft is at neutral the rudder is held stationary. The control shaft is connected through a follow-up mechanism (not shown in sketch) to a trick wheel and also to some part which moves with the rudder, so that the rudder follows the movement of the trick wheel. Connection between the steering wheel on the bridge and the trick wheel (actually the trick wheel shaft) can be made by any desired method, such as: wire rope transmission, hydraulic telemotor, or electric pilot motor and controller. If either of the first two methods are used there is an actual steering wheel on the bridge with follow-up control between it and the rudder. If the electric pilot motor is used its controller is placed on the bridge and non-follow-up control is obtained of the same nature as the present straight electric steering gears.

The efficiency of the hydraulic cylinders and the variable stroke pump is very high, while the efficiency of the right and left hand screw (usually used with the straight electric steering gear) is very low. Thus the amount of power required is much less with the electro-hydraulic than with the straight electric gear. Also by limiting the amount that the control shaft may be turned when the rudder is nearly at the hard-over position the maximum peak of the power required during the cycle of hard-over to hard-over can be considerably reduced. The combination of these two properties results in a very much less demand on the ship's electric generators when the electro-hydraulic design is used.

VENTILATION is provided to secure a circulation of air within the hull's interior and to replace foul air by fresh air taken from the outside atmosphere. Natural ventilation is provided by cowls and windsails, which, when trimmed to the wind, send fresh air below to replace foul air which is forced outboard through hatches, air-ports, etc., or through exhaust cowls which are trimmed from the wind to increase the rapidity of air circulation. Artificial ventilation is provided by steam or electric blowers, which drive fresh air from outboard and discharge it through ducts and louvres into the ship's interior; or which draw foul air from the interior and discharge it outboard. In large ships,

both of these artificial systems are frequently combined; one set of blowers supplying fresh air, and another set exhausting foul air. In all ships, natural ventilation is extensively provided, and careful attention to apparently small details is necessary to secure efficient circulation.

DRAINAGE: To provide for the removal of large quantities of water from the bilges, the *main circulating pumps* are provided with *bilge suctions* and are also usually connected to a *main drain pipe* of large size which generally extends from the forward fire-room bulkhead to the after engine-room bulkhead, with suitable valves permitting the inlet of water from any main compartment which is to be drained. There is also a *secondary drain* connected to numerous pumps, which enables small quantities of water to be removed from any compartment in the following manner: A metal chest called a *manifold*, containing a number of suitable valves, is located in a convenient position. One of these valves is connected by piping to an adjacent pump, another to the secondary drain, another to the sea, and each one of the remainder to some particular compartment above or within the double bottoms. To remove water from any compartment containing water, it is only necessary to open the valve connecting with that particular drainage pipe and the valve connecting with the adjacent pump, and then to operate the pump. In case the pump is not available for this purpose, the water can pass through the secondary drain to some other manifold whose pump is available. Thus, as shown on Plate **11**, if it be desired to pump water overboard from compartment A-99, which is connected by a pipe with suction S to a manifold valve B, all the valves leading to other suction pipes are closed, also the valve C, connecting to the secondary drain; the suction valve D of the pump X is opened and all others closed, the discharge overboard H, is opened, all other discharges closed, and the pump started, when it draws water directly from A-99 and sends it overboard. The water can be sent into the firemain by closing E, and opening F. The pump can be made to draw from the sea and discharge into the firemain by closing every suction except G, and every discharge except F. If it be desired to *admit* water into A-99, close C and all manifold valves except B, open H, and close G and D. Finally, if pump X is not available, pump Y can be readily used through manifold N, by opening C, closing D and H, opening C_2, G_2, and



SKELETON DRAINAGE PLAN SHOWING MANIFOLDS.

H_2, through which latter valve the water in A-99 can finally be discharged overboard. Many combinations of this type are provided, necessitating a complication of valves and piping in the bilges, but it is always necessary to ensure one set of valves being closed, and another opened in the manner outlined above.[1]

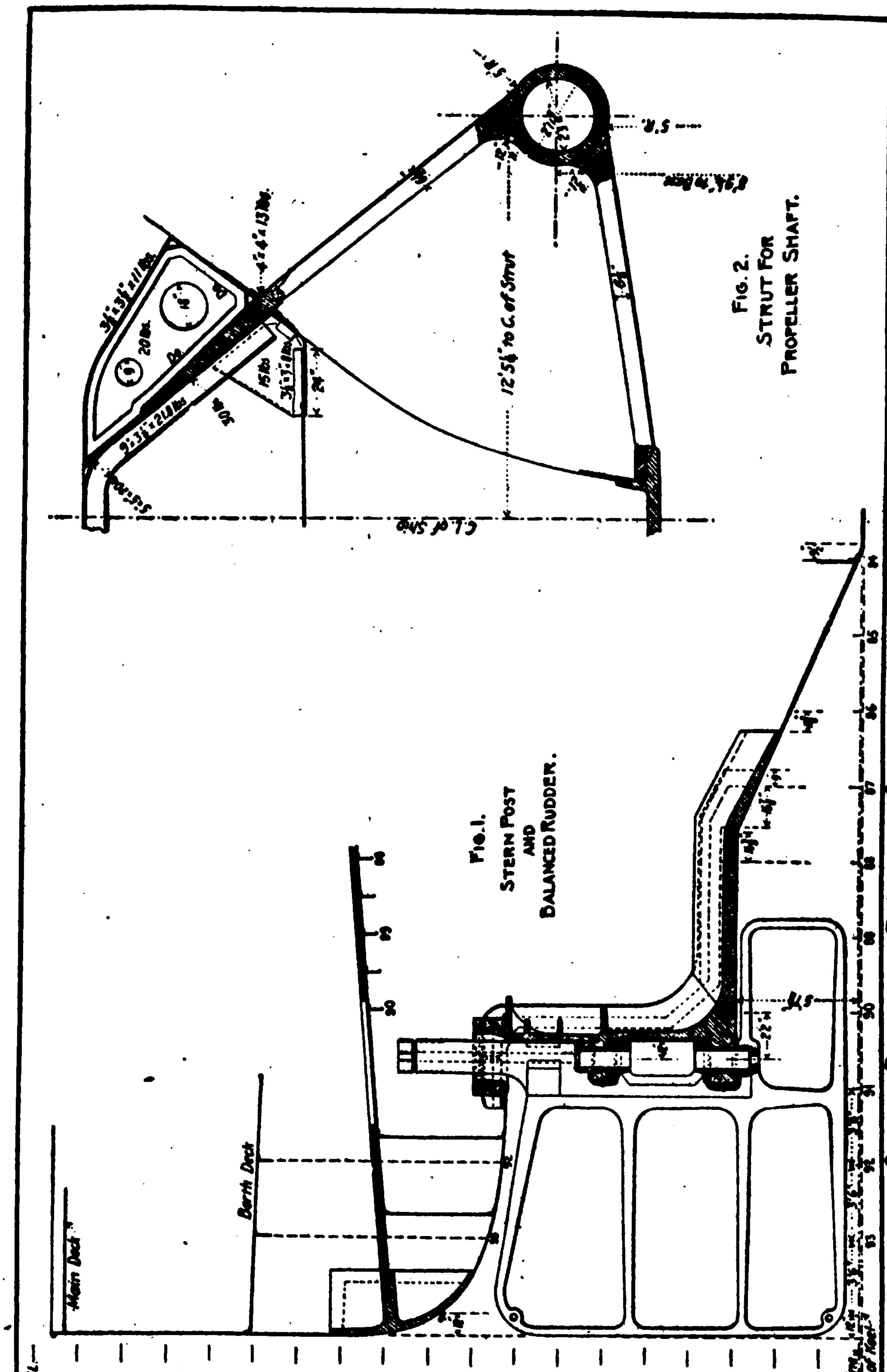
The Firemain usually consists of a copper pipe running fore and aft nearly the whole length of the ship, and placed on warships underneath the protective deck. It is connected to almost all pumps, both steam and hand, which draw water from overboard, so that any or all of them can be used to maintain it full of water under pressure. Numerous branches are located in suitable positions on the various decks, to which are attached hose plugs to furnish water for fire and wash-deck purposes. On recent warships the various upper outlets are connected by vertical branches to the firemain below the protective deck, each having a stop valve by which it may be cut off from the rest of the system; so that any one set of outlets may be disabled without disabling the others. Fire hose ready for instant use is stowed near each fire plug. Branches from the firemain are frequently led into the coal bunkers for use in extinguishing fires caused by spontaneous combustion. The salt water required for flushing the heads and lavatories is sometimes supplied from the firemain direct, and sometimes by a separate system of flushing pipes which are filled by certain special steam and hand pumps.

See Appendix for "**Pumps and their Uses.**"

Fresh water is carried in steel tanks which can be filled from shore, from water boats, or from the ship's own distillers; from these main tanks, it is usually pumped to one or more distributing tanks from which it flows by gravity through pipes to the necessary outlets at scuttle butts, state rooms, pantries, and galleys; in many cases, however, small hand pumps are located in convenient places and connected directly to the main tanks.

Magazines usually are flooded, when necessary, through pipes connected to the sea; one or more flood cocks being provided in each ammunition room, so aranged that they can be opened from the handling space and also from an upper deck. They are so arranged that they can be securely locked, and are provided with

[1] The seemingly complicated table supplied to all ships, giving lists of valves to be opened and closed for draining a particular compartment is simply an enlargement of the above outline.



Stern Post and Balanced Rudder Strut for Propeller Shaft.

indicators which show whether the flood cocks are shut or open. Air escapes leading to upper decks are provided, to let the magazines fill rapidly, overflow valves to prevent too great pressure upon the deck covering the magazine, and drain valves to permit the water to flow out when it is no longer needed. In large warships, a valve connected to the firemain is located in large ammunition rooms not greatly below the water-line, to ensure rapid flooding.

WATER-TIGHTNESS: The plates of the outer skin, bulkheads, and decks which are meant to be water-tight, are fastened by rivets, and the seams and butts are calked metal to metal; the planking of weather decks and of other wooden decks liable to be wet down, is made water-tight by filling the seams and butts with oakum or cotton, which is driven down thread by thread and afterwards covered with glue, putty, or pitch. Air-ports, gun-ports, coaling-ports, and similar openings in the outside plating above the water-line, are closed tightly by compressing rubber on suitable frames, using dogs, clamps, turn-buckles, etc. The openings in water-tight bulkheads and decks necessary for communication, are provided with water-tight doors, hatches, and man-holes; the two latter are usually made water-tight by compressing rubber with dogs and clamps, but the rubber is omitted in locations where wear is to be expected and some slight leakage will be of small consequence. Water-tight doors, however, are of such importance that special types are used; the hinged door in important bulkheads is made tight by rubber and clamping dogs, but the doors in the principal bulkheads which must necessarily remain open under ordinary service condition are usually arranged to slide, either vertically or horizontally, and become tight by wedging together two metal surfaces; this operation being performed at the door or at a distance from it, by various methods. The appliances for securing water-tightness vary greatly on different ships, *but the necessity for keeping all of them in efficient condition is of the highest importance;* if they are inefficient during an emergency, the elaborate subdivisions of the hull's interior into water-tight compartments may become worse than useless.

RUDDER AND PROPELLERS: The details of these are clearly shown on Plate **12**.

MISCELLANEOUS: There are numerous fittings attached to the hull which cannot be described in detail, but whose presence is essential. Some of the principal minor fittings are:

Mooring staples, attached to the outside of the hull, to which can be attached mooring chains or lines.

Portable davits and derricks, for hoisting boats, coal, and cargo, when the ship is in port, but which can be readily removed at sea.

Winches, fitted with drums and gypseys, for hoisting boats and cargo, handling anchors, and aiding the crew in handling lines.

Bitts, secured to various parts of the deck, with warping chocks or fair-leaders in their vicinity.

Pin-rails, fife-rails, belaying-pins, cleats, eye-bolts, and chain-bolts, are necessary for handling running gear.

CHAPTER II.

ROPE—KNOTTING AND SPLICING.

§ I. ROPE.

The rope commonly used on ship-board is of three kinds.

Hemp, tarred and untarred, Manila and Wire. Coir is sometimes used for heavy tow-ropes, for which it is particularly well adapted by buoyancy, but not by strength. Ropes are made also of flax and cotton, but these are not suitable for use at sea.

Full particulars as to ropes of all types used in the United States Navy are given in tables in the Appendix, which tables should be consulted in connection with this Chapter.

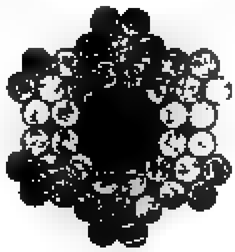
Much confusion results from the common practice of designating all ropes made from vegetable fibre, as "hemp." This mistake is almost universally made by other than sea-faring people in referring to manila; which is sometimes called "manila hemp," but oftener simply "hemp."

Hemp rope is made from the fibre of the hemp plant, which is cultivated extensively in many parts of the world, but especially in Italy, Russia and the United States. Russian and American hemp are very generally used for cordage in the United States.

Manila rope is made from the fibre of the stalk of the wild banana and comes principally from the Philippine Archipelago. As has been noted above, it is commonly designated as "Manila hemp."

Coir is made from the fibre of cocoanut husks. As it is very buoyant and does not become water-logged, it has a great advantage over hemp, manila, and wire, for some purposes, but unfortunately it has only about one-fourth the strength of manila.

In the manufacture of rope from the original fibres, these are twisted together into threads or *yarns,* which in turn are twisted into *strands.* A number of strands are laid up into a *rope,* and sometimes several ropes are combined to form a *cable.* (Plate 14.)



Type 1.
Transmission or Standing Rope.

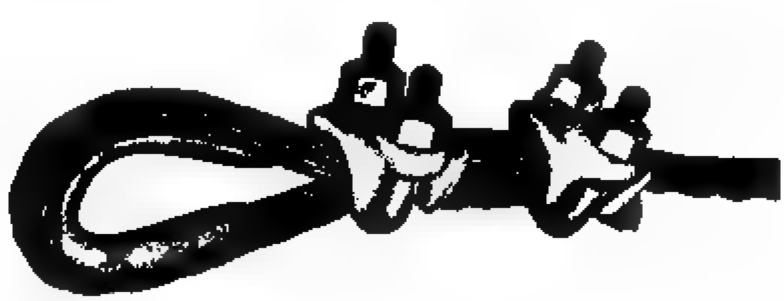
Type 2.
Hoisting Rope; Type "A" U. S. Navy.

Type 3
Special Flexible; Type "AA" U. S. Navy.

Type 4.
Running or Tow-Rope; Type "B" U. S. Navy.

Type 5.
Type "BB" U. S. Navy

Type 6.
Tiller and Hand Rope.



Wire Rope Clips. (Showing Method of Applying)

Wire Rope.

Note.—Type 6, U. S. Navy, used for hawsers, is identical with Type B, except that it has 14 wires in each strand.

Plate No. 14.

MANILA AND WIRE ROPE.

The twisting which is necessary in these various processes weakens the rope very materially; at least one-third of the original strength of the fibres being lost. On the other hand, the twisting adds considerably to the elasticity of the rope.

To counteract the tendency to unlay, the successive twists are taken in opposite directions; yarns being usually right-handed, strands left-handed, ropes right-handed, and cables left-handed. The above rule may be reversed, producing "left-handed" or "back-handed" rope.

Rope is commonly made with three strands, but four are sometimes used. In this case, the strands are laid up around a "heart" which fills the space that would otherwise be left within the rope. The rope thus produced is called four-stranded or "shroud-laid" rope.

Hemp rope as at present used is almost invariably tarred. In this form it is used for such of the standing rigging as is not of wire, and for the heaviest of the running rigging;—such as lifts, tacks and sheets of courses, topsail sheets, etc. The tar preserves the rope from deterioration due to the dampness, but reduces its strength and flexibility. Hemp when not tarred is know as "white-rope" and is the strongest rope used except wire.

Manila is used for most of the running gear, for reeving off purchases, and for the greater part of the miscellaneous work of the ship. It is somewhat weaker than untarred hemp, but does not deteriorate so rapidly from moisture.

Both the manila and the hemp rope of commerce vary greatly in quality. At their best, both should show a smooth, even surface when laid up, with few projecting ends of the fibres. When unlaid, the strands should show long and glossy, without admixture of short ends or "tow."

The strength of a rope-yarn varies from 75 to 100 lbs.

For special purposes, rope is sometimes plaited instead of laid. This does away with the tendency to kink.

Rope is designated as to *size* by its circumference, and runs from about three quarters of an inch to sixteen inches and even more; but the largest sizes are never seen on ship-board, twelve inches in manila and seven inches in wire being about the maximum that even the largest ship would carry. Its length is measured in fathoms.

Small cordage is usually known on ship-board as "small-stuff," and designated either by the number of threads that it contains, as "18-thread stuff," "15-thread stuff," etc.;—or as "Ratline stuff," "Seizing stuff," "Marline," "Spun-yarn," etc. These are usually of American hemp, tarred, and are measured in some cases by the fathom, in other cases by the pound.

The following are the most common varieties of small-stuff used on shipboard.

Spun-yarn. A rough and comparatively cheap stuff made from long tow and loosely laid up, left-handed, of two, three or four strands. It is more used on shipboard than any other variety of small-stuff, being convenient for seizings, service, etc., where great neatness is not required.

Houseline, Roundline and **Marline** are used for the same purposes as spun-yarn, but make neater work, being laid up more smoothly and of better material.

Marline is 2-stranded left-handed, houseline 3-stranded left-handed, and roundline 3-stranded right-handed. All of the above are used for seizings, but where a heavier and stronger material is needed, a higher grade of stuff is used, laid up by rope-making machinery and finished like the larger sizes of rope, although classed as small-stuff. This is called *Seizing Stuff*. It is usually 3-stranded, right-handed, and may have 2, 3 or 4 threads to the strand, making 6-thread, 9-thread or 12-thread seizing stuff.

Ratline Stuff does not differ from seizing stuff in its general characteristics, but is larger. It is 3-stranded, right-handed, and may have 4, 5, 6, 7 or 8 threads to the strand, making "12-thread," "15-thread," "18-thread" Ratline Stuff, and so on.

Rope-yarns are used for many purposes on board ship, and a good supply of them should always be on hand. They are made from condemned hemp cordage, tarred.

Two yarns twisted up together by hand, or single yarns twisted up against their natural lay and rubbed smooth, are called "foxes" and are often used for light seizings, being much neater than spun-yarn.

For further details as to *Cordage*, see Appendix.

Rope tends to contract when wet, and unless allowed to do so freely may be injuriously strained. It is for this reason and

to prevent danger to the yards, etc., that running gear is slacked in damp weather. On the other hand, advantage may be taken of this tendency for tautening lashings, etc., by wetting the rope.

As rope deteriorates rapidly from continued dampness, it should never be stowed away unless perfectly dry. This caution is especially important in the case of hawsers, which are rarely used without being wet. It is a reason also for the rule that hemp and manila block-straps should not be covered except when absolutely necessary, as the covering not only holds the moisture but prevents the deterioration from being seen.

Unlike the metals and other similar substances, rope made of vegetable fibre has not a permanent elastic limit within which it may be worked indefinitely without injury. Owing to the tendency of the fibres to slip one upon another, the rope gradually losses its cohesion under the repetition of very moderate tensions, and may be seriously weakened by constant working, without ever having been subjected to anything approaching a breaking stress; while if subjected even once to a stress approaching that of breaking, its strength is permanently reduced and it may be expected to give way under a very moderate pull.

Wire-rope is made of steel or iron wires laid up like yarns to form strands, which strands are in turn laid up to form a rope. The characteristics of the wire and the manner of making it up vary within wide limits in accordance with the purpose for which the rope is intended. Where great flexibility is wanted, as in the case of rope to be worked over pulleys, this quality is secured at some sacrifice of strength. Such rope should not be galvanized unless it is to be exposed to the weather or to extreme dampness. Where a steady stress is to be provided for, as in the case of standing rigging, the tensile strength is of maximum importance; and in this particular instance (standing rigging), galvanizing is essential because of the necessary exposure to weather. The number of strands will depend upon the purpose for which the rope is designed, as will also the nature of the heart. As a rule, six strands are used, laid up around a hempen heart. The number of wires to a strand may be anywhere from 3 to 50 or even more. Flexibility is secured by the use of a large number of small wires laid up around hemp

hearts to form strands which are in turn laid up, also around a hemp heart, to form the rope, and by the use of a comparatively sharp twist. Where flexibility is not important, the strands sometimes have wire hearts. This may add as much as 10 per cent to the strength, but would not do for any but stationary ropes, as the wear from the friction of a wire core upon the wire strands would be a serious matter for running gear, hawsers, etc.

Manufacturers commonly designate the size of wire rope by the diameter and this designation is used in circulars and in specifications, but seamen adhere to the habit of designating it like Hemp and Manila, by circumference.

Galvanizing is the simplest and most efficient means known of preserving wire from rusting, but it involves exposing the wire to a very high temperature, which for certain grades of steel may be injurious. A process of zinc electro-plating has been tried with considerable success, but has not come into general use, because of its expense.

Wire is used for most of the standing rigging of modern ships, and for pendants, spans, ridge-ropes, and other fittings. It is rarely used on ship-board for running gear except in a single pendant, or for tackles connected with steam or electric winches for hoisting boats and for other heavy work.

Wire hawsers are much used in towing, for which work they have many advantages and some serious disadvantages. (See Chapter on Towing.) They are coming more and more into use for general work, such as warping around docks, securing alongside, etc. For all of these purposes great flexibility is required, and great care should be taken to avoid sharp bends, and not to kink the wire. If hawsers are supplied for towing, they should never be used to tie up the ship, and never subjected to a sharp nip.

Wire-rope requires in some ways better care than hemp or manila and far better care than it generally receives on shipboard. It should be kept on a reel when not in use. *A single kink in the finest wire-rope practically ruins it at once.*

A wire hawser should be gone over thoroughly every month or two with raw linseed oil; or, better, if it is not to be used for some time, with a paint made of equal parts of linseed oil and lamp-black. Neither oils nor tars can be regarded as perfect preservers, as they all contain more or less acid, which attacks the steel. The principal reliance must therefore be upon the galvanizing. If the rope is to remain under water for some time, the best preservative is made by adding to one barrel of Stockholm tar, one barrel of fresh slaked lime. Boil well and use while hot for saturating the rope.

Wherever wire-rope is to be worked *over a sheave,* the diameter of the sheave and the speed of running become very important factors. The larger the sheave and the lower the speed, the better. All manufacturers of wire-rope prescribe a minimum diameter for sheaves, and their guaranteed breaking strains and estimated safe-working loads are for these minimum diameters, and for moderate speed. A high speed increases the wear upon the rope, not only by the friction on the pulley, but still more by the friction of the wires upon each other—a point which is often overlooked.

The importance of this *interior friction* will be realized if we consider the "play" which necessarily goes on between the fibres of a rope which is being alternately bent and straightened in running over a pulley. This play of course increases with the speed, and is greater with a small sheave than with a large one. The same consideration enters in where a rope is alternately stretched and relaxed under a straight but varying pull, as for example, in towing. This emphasizes the importance of interior lubrication.

A **hemp core** (Plate 14) holds the lubricating material in the heart of the rope, and gives it out under pressure of a heavy strain. This is one of the most important reasons for preferring hemp to wire for the core, although the primary reason has to do with flexibility.

In a comparative test, an unlubricated rope broke after 16,000 bends, while the same rope, well lubricated, stood 38,700 bends.

A still further advantage of the hemp core is that it forms a *cushion* upon which the strands close in as the rope contracts under a heavy pull, thus acting with the elasticity of the wire

and the "give" which results for the spiral lay, to relieve the effect of sudden stresses.

In addition to the question of friction in running over a sheave, the *distortion* of the rope wherever it passes around a relatively sharp bend, whether on a moving pulley or a stationary chock or bollard, is a factor of great importance. Those fibres which lie farthest from the centre of the curve are stretched, while those which hug the round of the bend are more or less compressed. Thus the outer fibres may give way before the inner ones begin to feel the strain.

Wire-rope is habitually kept on reels. In receiving a line and transferring it from one reel to another care should be taken to *unreel it,* instead of slipping off the successive bights over the end of the reel, as is sometimes done.

While the strength, lightness and durability of wire-rope are important factors in its favor, its most valuable characteristic, as compared with hemp, manila, and chain, is its *reliability.* Within its proper working limits, it almost never fails.

Hemp and manila may be rotten at the core and show no sign, or they may have been weakened by excessive strains and give no indication of it except, perhaps, that they are a little "long-jawed." A chain may be made of worthless material, or, if of the best material and made with every care, it may have flaws which no inspection can reveal.

Hemp and manila ropes are made up of a great number of fibres from a few inches to several feet in length. Wire-rope is made of a small number of wires of the full length of the rope, each of which is manufactured, inspected and tested, individually, throughout its full length, before it goes into the rope. The inspection is so simple that a flaw can hardly be overlooked and it is most improbable that any number of wires can have flaws which in the end appear at the same point of a strand. Thus it is almost impossible that any serious flaw should exist in a wire-rope *as manufactured.*

A flaw due to kinking can always be seen.

An *accident* with wire-rope is almost necessarily due to carelessness.

Assuming the rope to have a well-lubricated hemp core, and to be used only over properly proportioned pulleys, the outside strands will be the first to wear out, and the reduction in their diameter becomes the measure of the wear of the rope as a whole.

The rule given by manufacturers is that *the rope should be discarded when the outside wires are reduced to one-half of their original diameter.*

The suitability of a rope for any given purpose depends not only upon its strength but upon several other qualities. For certain purposes, flexibility is more important than strength. In cases where much wear is involved, it is desirable that the individual wires should be fairly large, so that the outside wires shall not wear through too quickly. For standing rigging, a wire core is admissible, while for running rigging of all kinds a hemp core is absolutely necessary. If a rope is to be exposed to the weather it must be galvanized; otherwise, not.

It is important, in ordering wire-rope, to specify the purpose to which it is to be applied, and as many of the conditions of its use as practicable.

Types of Wire-Rope.

PLATE 13 shows various types of wire-rope for different purposes: As a rule, these are made commercially in the following grades of material, the comparative strength being as indicated, taking the best wrought iron rope as unity.

Wrought iron	1
Crucible steel	2
Plow steel	2½
Monitor steel	3

All wire-rope for the United States Navy is made at the Boston Navy Yard, and except where otherwise specially stated, is of crucible steel. Certain sizes of Type A are made in plow steel as well as in crucible.

Crucible steel has a tensile strength of 220,000 lbs. per square inch; plow steel, 260,000 lbs.

For strength and other particulars as to various types, see tables in Appendix.

Type 1 is the most inflexible rope manufactured, being made up of a small number of large wires. When used around a drum for the transmission of power, the diameter of the drum should

be as large as possible. A minimum diameter of 10 feet is specified for a rope 4 inches in circumference.

Type 2 (Type **A**) is used in the Navy for standing rigging and in some cases for wheel-ropes and running-gear, but this only in small sizes and with one or two parts working over large sheaves. As its individual wires are large, it is well suited to stand abrasive wear.

Type 3 (Type **AA**). This type is much more flexible than Type 2 (**A**) and has practically the same strength. It is used for crane falls and other running-gear in large sizes, for which Type 2 would be too stiff. It is used also for special hawsers, where great strength is required, combined with good flexibility, but is only issued for this purpose on special orders, Type 4 being the usual type for hawsers. Being made of smaller wires than Type 3, it is not so durable, as the wires chafe through, weakening the rope and making it rough and hard on the hands.

Type 4. (Type B.) Running and Tow Ropes.

This is the most flexible rope made for general use, but has only about 75 per cent the strength of Types 1, 2 and 3. It is used for running rigging and for hawsers. Its flexibility makes it available for many purposes for which a stiffer rope would be altogether unsuitable, such as securing a ship to a dock, where turns must be taken around cleats and bollards, and where bends more or less sharp are unavoidable. In spite of its comparative flexibility, however, care should be taken to make all bends as large as possible and to treat the wire with all consideration. In the case of running rigging, much smaller sheaves may be used than in the case of Type 3, but the sheaves should nevertheless be made as large as is practicable. This type is well adapted for use with an automatic towing machine. It is the type commonly used also for towing without a machine, but for this it is distinctly inferior to Types 3 and 5.

Under the designation Type B, this rope is issued to the Navy for running-gear.

Type C, which is used in the Navy for hawsers and tow-lines, is identical with B except that it has 14 wires to the strand instead of 12.

Type 5. (Type BB.)

This type has about 10 per cent less weight and strength than Type 1 (see Table). It is much stronger than Type 4 and only a little less flexible. It gives, in fact, about the best combination known of flexibility and strength and is well fitted for towing, though it is not issued for this work unless specially ordered.

Type 6. Tiller Rope.

This is the most flexible wire-rope made, but is not strong enough for general use. As its wires are small it is not well suited to stand abrasive wear. It is made only in small sizes.

RULES FOR WORKING LOAD.

1. Under average conditions,

Working load=1/6 breaking stress.

2. Under best conditions—new rope to be used occasionally,

Working load=1/4 breaking stress.

3. Under unfavorable conditions, where rope is used frequently and for an indefinite period, as in the case of running rigging and boats' falls,

Working load=1/8 breaking stress.

(See also, Rules at end of Chapter IV.)

Fig. 3, Plate **14**, shows a handy "clip" and the manner of applying it. These clips, when made of forged steel and properly applied, are little, if at all, inferior to a splice. And they can be applied in a few moments where a splice would take as many hours. In the emergencies which sometimes arise on shipboard, as in handling anchors, taking a vessel in tow, etc., when an eye is needed in a hawser and there is not time to make a splice, these clips would be invaluable. They can be removed as quickly as they are applied, breaking down the eye at once.

A set of these in sizes to fit any hawser on board might well be issued to all men-of-war.

PLATE **22** shows a *check stopper* and an *ordinary stopper*, applied to wire-rope. These are best made of small open-link chain, although manila is sometimes used.

§ II. KNOTTING AND SPLICING.

The art of working in rope cannot be learned from a book, but the illustrations which accompany this Chapter will give an idea of the most common knots, splices, etc., in general use and should be helpful up to a certain point in making them.

PLATE **15** shows a number of simple knots, all of which are made with a single rope.

An Overhand Knot. Fig. 1.

A Bowline. Fig. 2. One of the most common and useful knots known to Seamanship. It forms a loop, which may be of any length, and which cannot slip, as the heavier the pull upon it, the tighter it jams. Moreover, it does not form so sharp a nip as to weaken the rope. It is used for lowering men over a ship's side, for slinging them from stays, etc., while working aloft, and for a great variety of similar purposes. A common use of it is to form a loop in the end of a hawser to be thrown over a bollard, in working a ship alongside a dock.

A Running Bowline. Fig. 3. A convenient form of running loop. The loop of the bowline proper is usually smaller than that shown in the figure.

A Bowline on a Bight. Figs. 4 and 5. Used in place of a single bowline where greater strength is needed, or an increased number of parts.

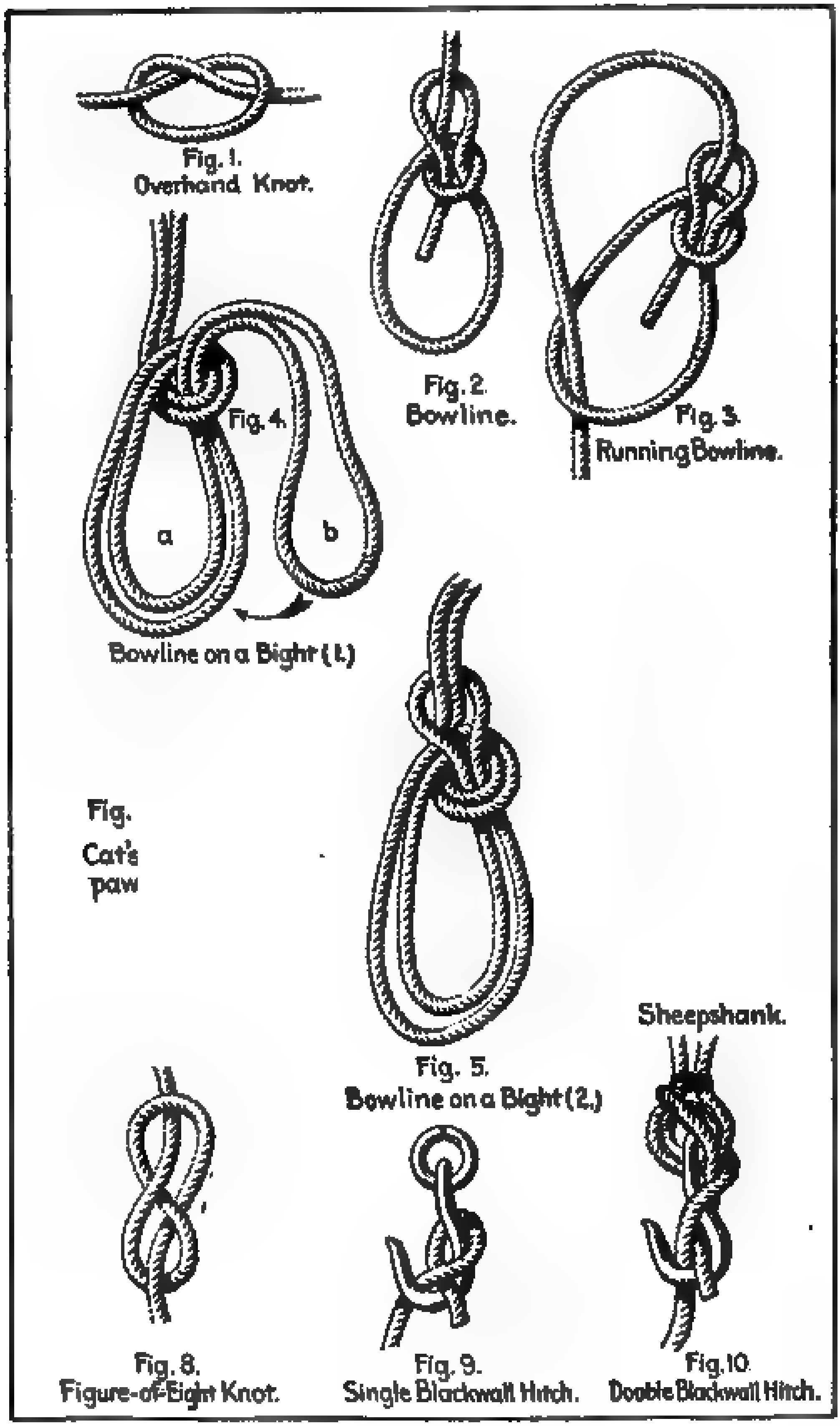
A Cats-paw and **a Blackwall Hitch.** Figs. 6, 9 and 10. Used for hooking a tackle to the end of a rope. The double Blackwall is sometimes called a **Stunner Hitch.**

A Sheep-shank. Fig. 7. A quick and convenient way of temporarily shortening a rope.

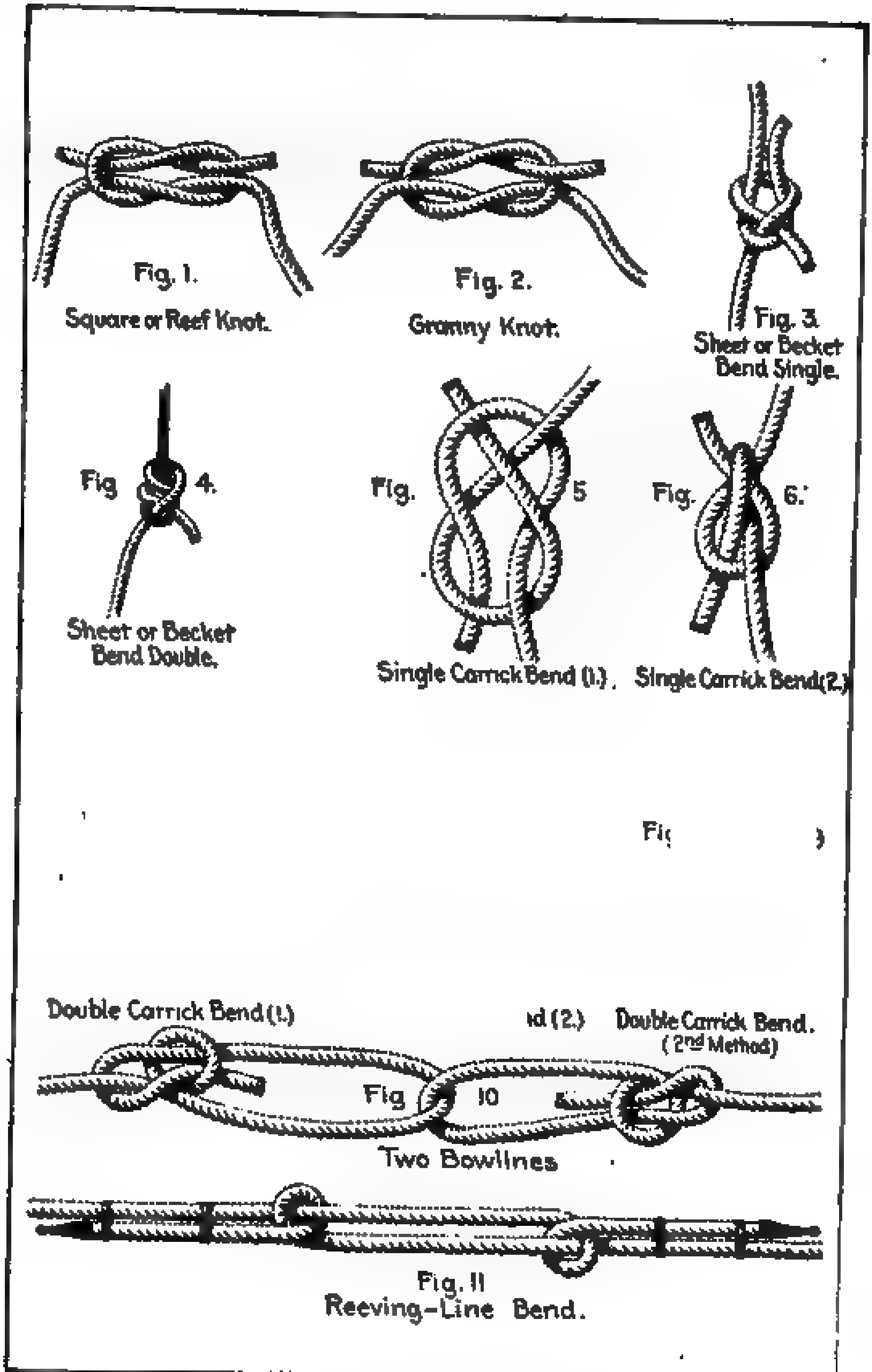
A Figure-of-Eight-Knot. Fig. 8. Turned in a rope to prevent it from unreeving. It will not jam as an overhand knot would do.

PLATE **16** shows the most common knots used for connecting two ropes or two ends of the same rope.

A Square-knot or **Reef-knot.** Fig. 1. This is the simplest knot of the series and the most useful. It should be carefully distinguished from the "Granny-knot" (Fig. 2), which does not hold as well and is hard to untie. A square-knot will not answer for uniting ropes of different sizes, as the parts would slip unless stopped down.



KNOTS IN THE END OF A ROPE.



BENDING TWO ROPES TOGETHER.

A Sheet or **Becket Bend.** Fig. 3. Called by landsmen a "Weaver's Knot." May be used where the parts are of different sizes.

A Sheet Bend, double. Fig. 4.

A Single Carrick Bend. Figs. 5 and 6.

A Double Carrick Bend. Figs. 7, 8 and 9. Commonly used for bending hawsers together. If the two parts are of different sizes it is well to seize each part back on itself.

Two Bowlines, Fig. 10, and a **Reeving-line Bend,** Fig. 11, are also used for bending hawsers together. The reeving-line bend is particularly useful where the lines are to be veered out through a small pipe.

PLATE **17.** The figures of this plate show a number of methods of securing lines to spars, posts, rings, etc.

A Studding-Sail Tack Bend. Fig. 1. Will not come adrift by the flapping of the sail.

A Studding-Sail Halliard Bend. Fig. 2. Lies flat to the yard.

A Fisherman's Bend. Fig. 3.

A Timber Hitch. Fig. 4.

A Timber and Half Hitch. Fig. 5. For towing or dragging a spar.

A Rolling Hitch. Very useful where one rope is to be bent to the standing part of another rope, or to a spar.

A Round Turn and Two Half Hitches. Fig. 7. For making a hawser fast to a bollard. For greater security, the end should be stopped down to the main part. If the part *a* is taken up under *b* as well as under *c*, we have a Fisherman's bend, which, with a half hitch outside it as at *d*, is often used for this purpose. A more convenient way is to turn a bowline in the end of the hawser and throw it over the post.

PLATE **18** shows a series of knots which are worked in the end or the body of the rope by unlaying the rope and using its own strands. A whipping is usually put on below the point where the knot is to be. Knots of this kind are sometimes used to give a finish to the end of the rope, sometimes to prevent it from unreeving, and sometimes merely for ornamental purposes.

A Wall-knot. Fig. 1.

A Wall and Crown. Fig. 2.

A Double Wall and Single Crown. Fig. 3.

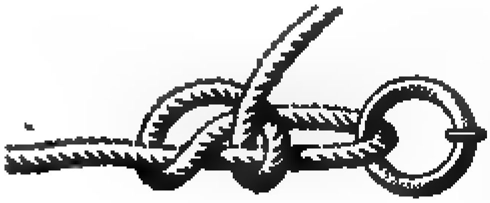


Fig. 1.
Studding Sail Tack Bend.

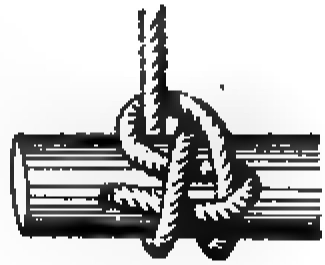


Fig. 2.
Studding-Sail Halliard Bend.

Fig. 3.
Fisherman's Bend.

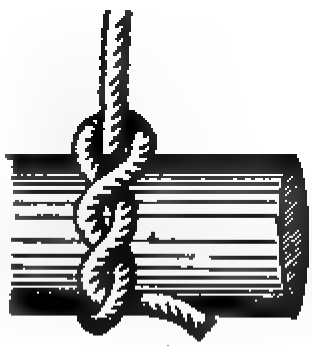


Fig. 4.
Timber Hitch.

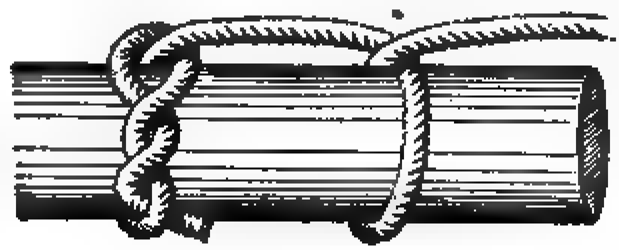
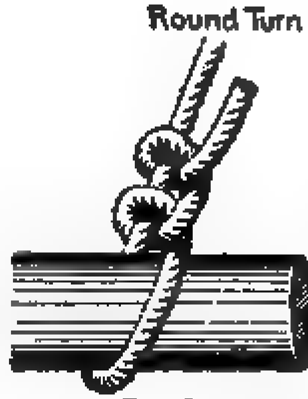


Fig. 5.
Timber and Half Hitch.

Round Turn and Two Half Hitches.



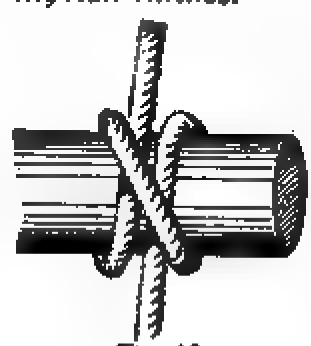
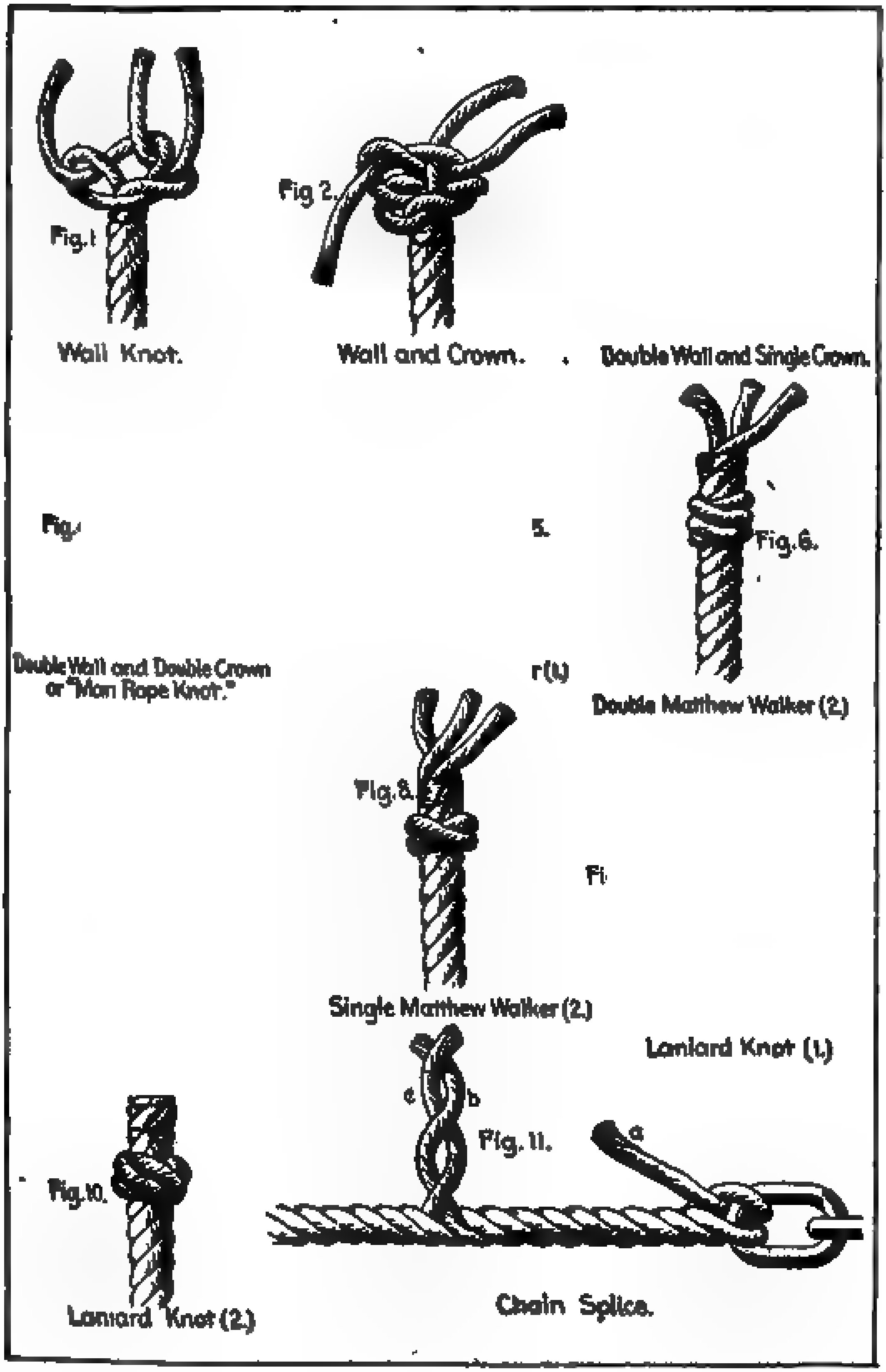


Fig. 8.
Rolling Hitch.

Fig. 9.
Two Half Hitches.

Fig. 10.
Clove Hitch.

BENDING A ROPE TO A POST OR SPAR.



KNOTS WORKED IN THE END OF A ROPE

Plate No. 19.

1

Fig.

Eye Splice.(1)

Eye Splice.(2)

Eye Splice.(3)

Fig

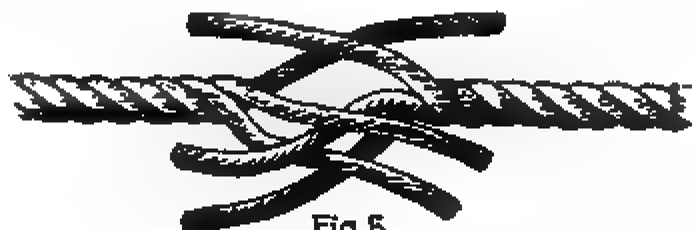


Fig. 5.
Short Spli

4

Fig. 6.
Short Splice.(2)

Sailmaker's Eye Splice.(1)

Fig. 8.
Short Splice.(3)

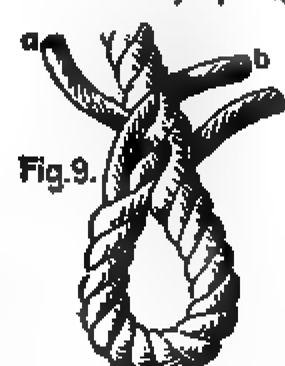


Fig. 9.

Sailmaker's Eye Splice.(2)

SPLICES.

A Double Wall and Double Crown or "**Man-rope Knot.**" Fig. 4. Used on the ends of "man-ropes" (trailing-lines over the sides) to give a good hold for a man overboard.

A Matthew-Walker Knot, double and single. Figs. 5 and 6, 7 and 8.

A Lanyard Knot. Figs. 9 and 10. Used on the end of a lanyard to prevent unreeving through the dead-eye.

A Chain Splice. Fig. 11. For splicing a rope to a chain.

PLATE **19** shows various forms of **splices** for joining the ends of two ropes permanently, or for bending back the end of a rope upon itself to form a permanent eye. In cases like this and those which follow, when the strands of a rope are to be *tucked,* the lay of the rope where they go through is opened out by means of a marline-spike, and the strand tucked through once in its full size, then reduced in size by cutting away a certain number of threads; tucked a second time, reduced once more in size and tucked again. It is thus tucked once full size, once two-thirds, and once one-third. This produces a tapered and much neater splice than if it were tucked three times in full size.

An Eye-splice in three-stranded rope. Figs. 1, 2 and 3. The rope is unlaid for perhaps a foot from the end, and the strands brought back upon the body of the rope at a point which will form an eye of the size that is wanted. Beginning with any one strand, this is tucked from left to right, through the strands of the rope (which are opened out by a spike), being passed over one and under the next. The other two strands are similarly tucked, always from right to left. All three are then trimmed down to two-thirds their original size, tucked again, trimmed to one-third size and tucked a third and last time.

An Eye-splice in four-stranded rope. Fig. 4. Here the first strand is tucked under two; but this for the first tucking only.

A Sailmaker's Eye-splice. Figs. 7 and 9. Used on the roping of sails because it continues the original lay of the rope around the eye and is thus more convenient for sewing to canvas.

A Short Splice. Figs. 5, 6, and 8. Two ropes are unlaid for a short distance and married together with strands interlacing (Fig. 5). The strands of each rope are then tucked through the lay of the other rope exactly as has been described in the case of an eye-splice.

PLATE **20. A Long Splice.** Figs. 1 and 2. Here the ropes are unlaid for a greater distance than for a short splice and the ends brought together as before, with strands interlacing. Instead now of tucking at once, we proceed as follows: Unlay a_1 one of the strands of A, for a considerable distance, and in place of it lay up b_1 the adjoining strand of B, thus working a strand of B into A, for, say, a foot and a half or two feet. For convenience now twist up a_1 and b_1 together temporarily, as in Fig. 2. Turn the rope end for end, unlay b_2 one of the strands of B, and in place of it lay up a_2 the adjoining strand of A. a_3 and b_3 are left lying beside each other without being unlaid. We now have three pairs of strands at different points of the rope. Beginning with a_2 and b_2 (for example) separate each of these strands into two parts, and taking one-half of each strand, overhand knot these together (K. Fig. 2) and tuck them as in a short splice, over one and under one of the full remaining strands of the rope. (M. Fig. 2.)

The other pairs of strands (a_1 b_1) (a_2 b_2) are similarly reduced, knotted, and tucked. The spare half of each strand is trimmed off smooth, as are the ends of the other halves after they have been tucked.

WORKING IN WIRE-ROPE.

As already stated, wire-rope is usually six-stranded, with a hemp heart. In splicing, we may work with the strands separately or in pairs. The work calls for special appliances and for a degree of skill such as can be acquired only by long practice under expert instruction. Something may be learned from careful description, and much more from an occasional visit to a rigging loft; but the facilities which are available on ship-board do not admit of doing such work as is possible with a rigger's bench, a turning-in machine, etc. Where a heavy rope is to be bent around a thimble or the parts otherwise brought together for splicing or seizing, a rigger's-screw is needed. In the absence of this, a vise may be used, but less conveniently.

In tucking the strands of a splice, the lay of the rope is opened out and *the spike left in,* holding the strands apart, until the tuck has been made. For dragging the strands through, a jigger is used on each one, the body of the rope being held by another jigger or a lashing. After a tuck, the parts of the ropes are ham-

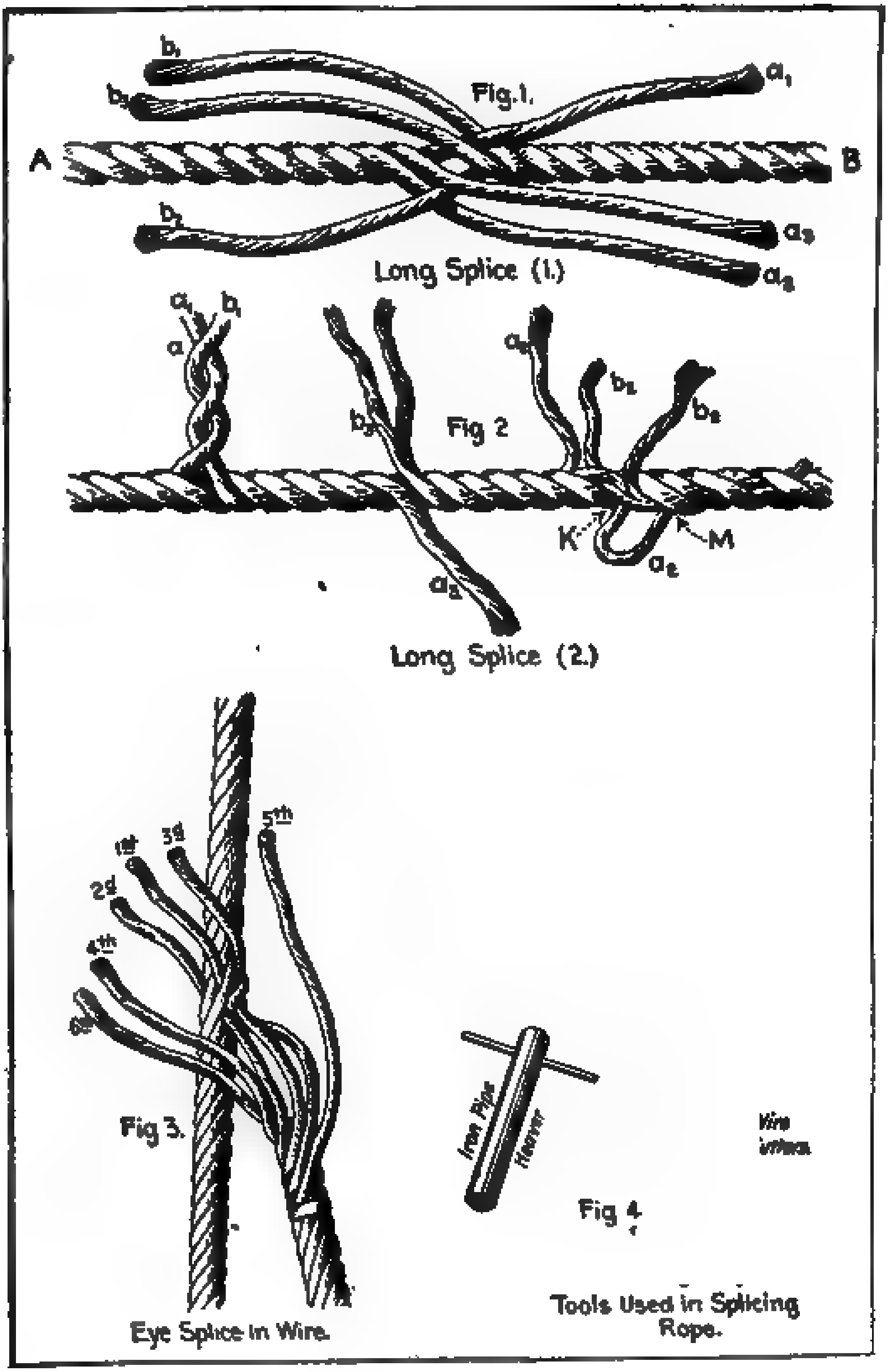


Fig. 1.
A
B
Long Splice (1.)
Fig 2
K
M
Long Splice (2.)
1st
2d
3d
4th
5th
6th
Fig 3.
Eye Splice in Wire.
Iron Pipe
Hammer
Fig 4
Tools Used in Splicing Rope.

SPLICING.

Plate No. 21.

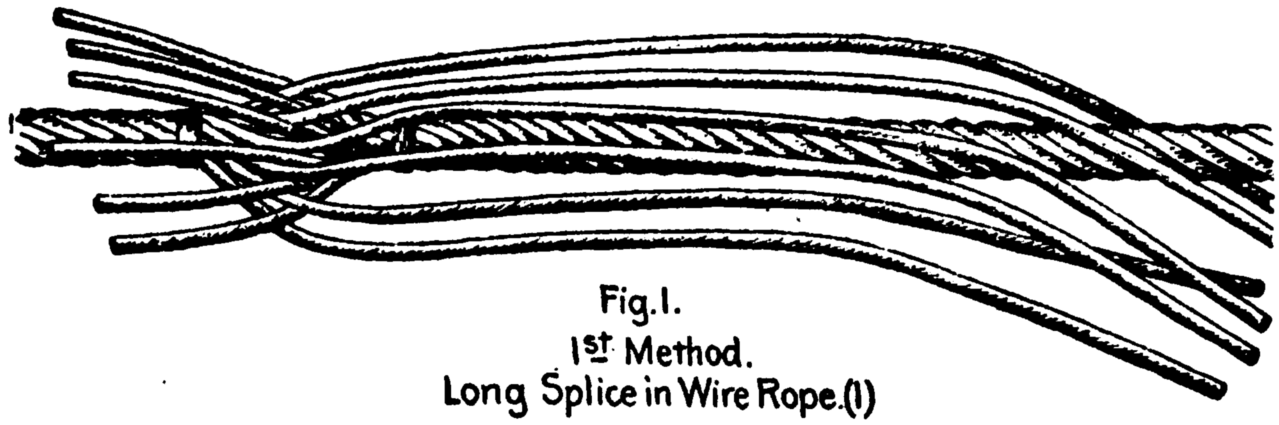


Fig. 1.
1st Method.
Long Splice in Wire Rope. (1)

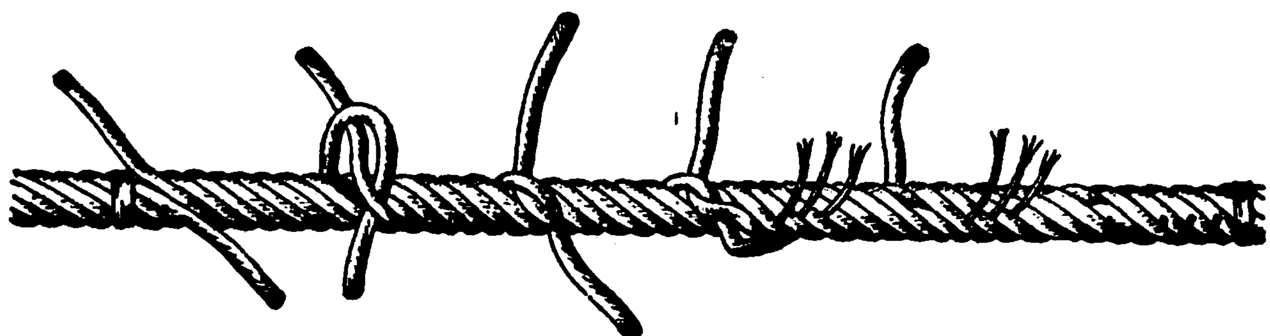


Fig. 2.
1st Method.
Long Splice in Wire Rope. (2)

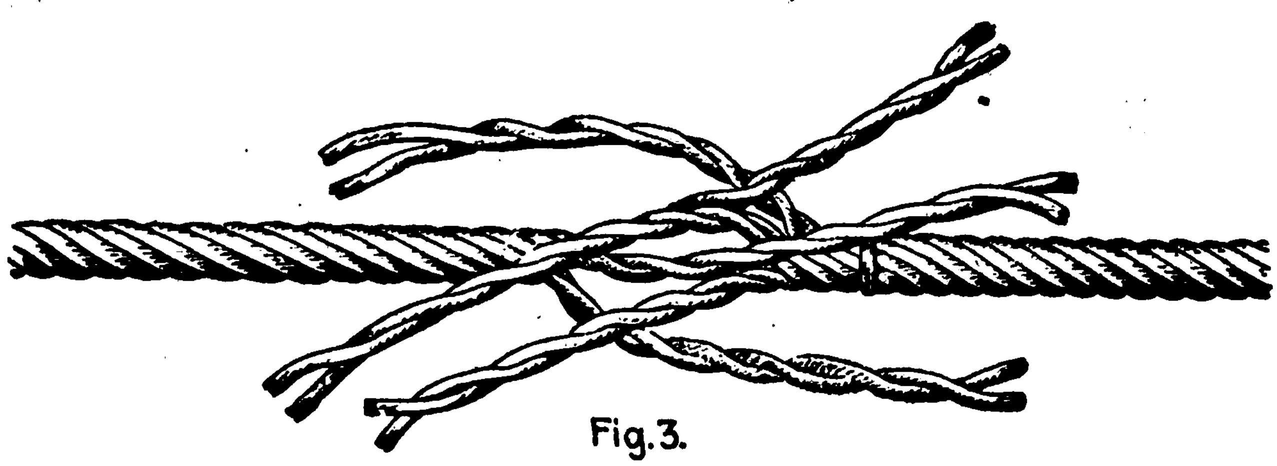


Fig. 3.
2d Method.
Long Splice in Wire.

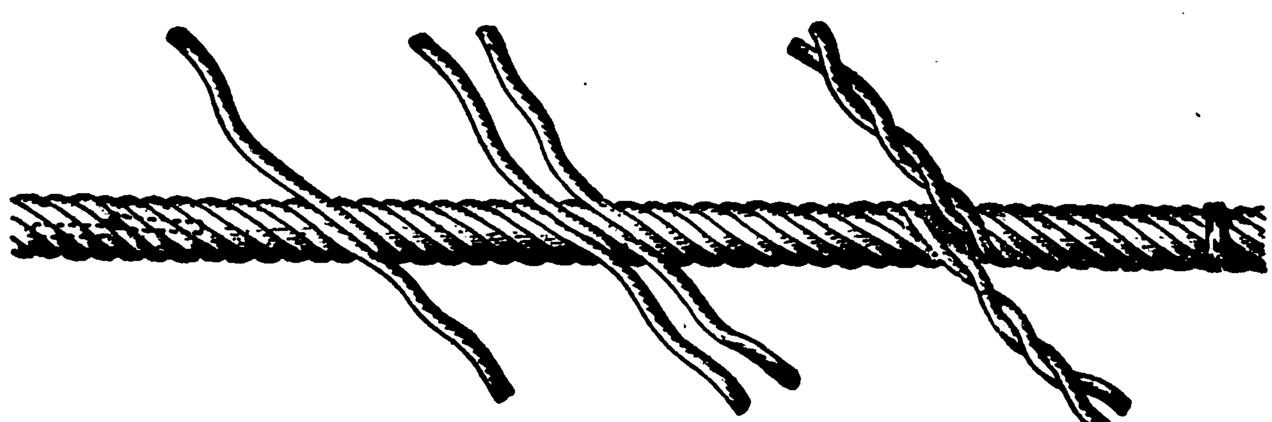


Fig. 4.
2d Method.
Long Splice in Wire.

LONG SPLICE IN WIRE.

mered down tightly upon each other. Wire-cutters are used for cutting off ends.

Fig. 4, Plate **20**, shows the tools used in working in wire on shipboard.

PLATE **20**. **An Eye-splice in Wire.** Fig. 3. Get the rope on a stretch, allow from 18 to 24 inches from the end for splicing, and put on a mark with a couple of turns of twine. Measure along the rope from this mark the length of the eye (once and one-half the round of the thimble) and put on another similar mark. Paint with red lead, worm, parcel, paint again, and double-serve between the marks. Now come up the stretch and seize the thimble in, breaking the rope around by the rigger's-screw and putting on a good racking seizing around both parts. Come up the screw, unlay the end of the wire, and cut out the heart close to the service. Now, with the thimble toward you, counting from right to left 1, 2, 3, etc., stick No. 4 strand from right to left under the upper strands of the rope just clear of the service, opening the strands by a spike. Haul through by hand. In the same manner—under two and over one strand—tuck the remaining strands, in the following order: 3, 5, 2, 6, 1. Now, commencing with any strand, tuck again whole and haul through by means of a jigger. Hammer the strands down in place, cut each strand down to one-half size and tuck again, hauling through with a jigger as before. Cut the strands down to one-quarter and tuck again. Hammer down all strands and cut off the wire with a wire-cutter.

PLATE **21**. **A Long Splice in Wire.** Figs. 1 and 2. Put on a good seizing six to ten feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one to two feet from the end of the other rope. Unlay, open out the strands, cut out the heart, and marry the ends together with strands interlacing. Cut the seizing on the short end. Unlay one of the short strands, following it up in the same lay with the opposite long strand, leaving end enough to tuck. Continue in the same manner with the remaining strands, except as to the distance to which they are laid up, this distance being varied in such a way as to leave the successive pairs an equal distance apart, as shown in Fig. 2. Commencing with any two strands, half knot them together (full size), then divide each into three parts, and tuck these parts separately as shown;—or,

cut out a few inches of the heart and insert the ends of the strands in its place in the centre of the rope. When a splice is to be served, the latter way of finishing it off answers very well, but not otherwise.

Note that this splice is made by working always to the right, the strands of A (long strands) being all worked into B.

A Long Splice in Wire. Figs. 3 and 4 (second method). Put on a good seizing an equal distance from the ends of the ropes to be spliced, from six to ten feet, according to the size of the rope. Unlay the strands *in pairs,* cut out the heart, marry together (Fig. 3), and lay up the strands in the same manner as in an ordinary three-stranded long splice in hemp, so that the strands meet an equal distance apart (Fig 4). Then take any two ends (double strands), separate the strands, unlay one of these single strands, of A for example, and follow up in the lay with one of the corresponding single strands of B. The other single strand of A in the original pair, is left, with the corresponding single strand of B lying alongside of it. This is repeated with each of the original double strands. There are now six sets of single strands of A and B lying together at different points of the rope, ready for tucking. The splice is finished off either by overhand knotting these ends, or by inserting the ends in place of the heart.

In view of the difficulty and delay involved in splicing wire rope, it is often convenient to make use of other methods for making an eye or for joining two ropes temporarily. Attention has been called to the use which may be made of the clamps shown in Plate 14. These are quickly and easily applied, and where several of them are used together, they may give nearly or quite as strong a connection as a splice.

PLATE **22.** **A Short Splice in Wire.** Fig. 1. Put on a good seizing two or three feet—according to the size of the rope—from the end of one of the ropes to be spliced, and a similar seizing one or two feet from the end of the other rope. Unlay the ends and open out the strands, cutting out the heart close to the seizings. Marry them together and clap on a temporary seizing around the short ends and the body of the rope, to hold the parts close together. Commencing with any one of the long strands, tuck each in succession over one and under two strands, opening out the lay with a spike. Tuck the remaining strands in the same manner;—twice whole strands, once one-half, and once

Fig. 1.
Short Splice in Wire.

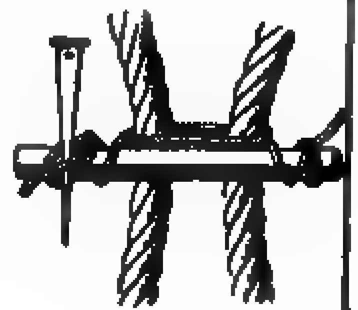


Fig. 2.
Spanish Windlass.

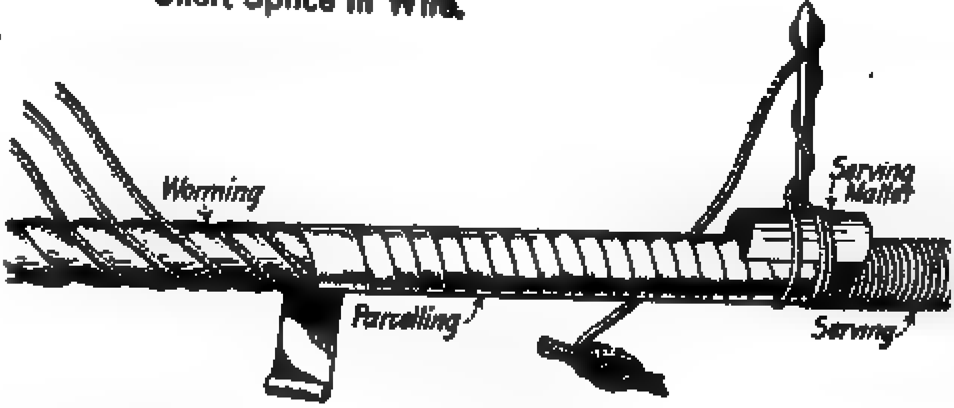


Fig. 3. Worming, Parcelling and Serving.

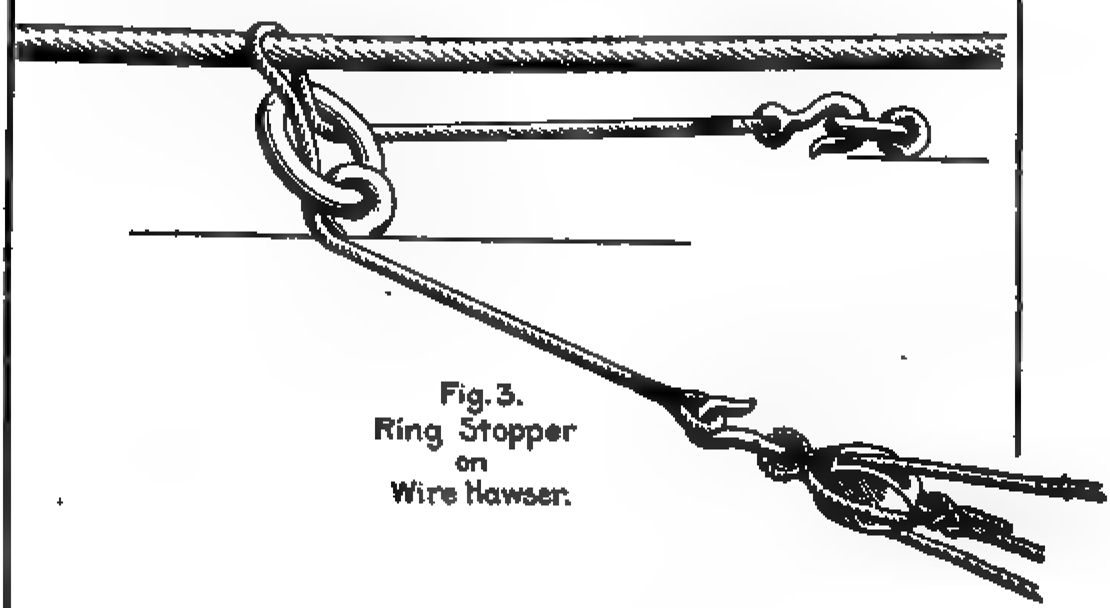


Fig. 3.
Ring Stopper
on
Wire Hawser.

MISCELLANEOUS.

Plate No. 23.

Fi

Fi

Fig.

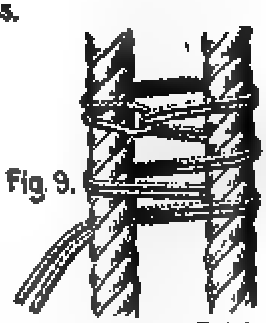
Fi

Ro

Round Seizing without Cross.
Overhand Knot
Finish

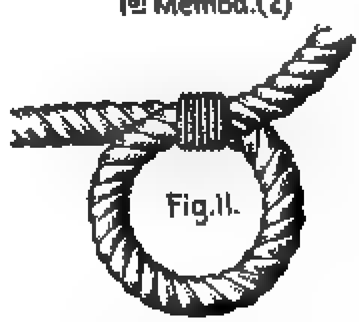
Round Seizing.
2d Method.

Fig. 9.



Racking Seizing.
2d Method

Racking Seizing.
1st Method.(2)



Throat Seizing.

Rose Lashing.

SEIZINGS.

one-quarter, hauling through with a jigger each time. Then turn the splice around, cutting the temporary seizing on the short ends, and tuck the short strands once one-half and once one-quarter, heaving them through with a jigger. Hammer down all parts and trim off the ends.

A Spanish Windlass. Fig. 2.

For heaving two parts of a rope together.

PLATE **23** shows different forms of seizings for binding together two ropes or two parts of the same rope. The manner of passing them is made clear by the figures. With heavy ropes, the parts must be hove together by power of some kind, such as a Spanish Windlass, a rigger's-screw, or a turning-in machine.

Worming, Parcelling, and Serving (Plate **22**.) Rope which is to be exposed to the weather or to exceptionally hard usage is protected by worming, parcelling, and serving.

Worming consists in following the "lay" of the rope, between the strands, with small-stuff, tarred, which keeps moisture from penetrating to the interior of the rope, and at the same time fills out the round of the rope, giving a smooth surface for the parcelling and serving.

Parcelling consists in wrapping the rope spirally with long strips of canvas, following the lay of the rope, and overlapping like the shingles on a roof to shed moisture.

Serving consists in wrapping small-stuff snugly over the parcelling, each turn being hove taut as possible so that the whole forms a stiff protecting cover for the rope. A "serving-mallet" is used for passing the turns, each turn being hove taut by the leverage of the handle as illustrated in Plate **22**.

CHAPTER III.

MECHANICAL APPLIANCES ON SHIP-BOARD.

The successful use of mechanical appliances on ship-board calls for a familiarity with certain elementary principles of mechanics which may thus be properly regarded as a part of Seamanship.

From this point of view they will be treated here as preliminary to the handling of heavy weights.

The popular conception of forces and of the manner of measuring them may be accepted as sufficiently exact for our present purpose.

The Composition and Resolution of Forces.

For every force acting upon a body there is a certain "line of action" along which it tends to move this body. If several forces act upon the same body at the same time, the total effect produced will be, both in magnitude and in direction, a combination of the effects of the individual forces; and it is found that we may substitute for any such combination of forces, a single force of definite magnitude and direction; and that the magnitude and direction of this "resultant force" as it is called, may be deduced from the original forces by a very simple construction.

The derivation of a single resultant from several distinct forces is called "The Composition of Forces."

It is found also that we may reverse the above process, and, from a single given force, find two or more forces acting along given lines which may be substituted for the one original force without any change in the effect produced. This process is called "The Resolution of Forces"; and the forces resulting from it are "components" of the original force from which they are derived. In discussing these principles and applying them to practical problems, we may conveniently denote a force by a *line* of a certain length, the number of units of length taken

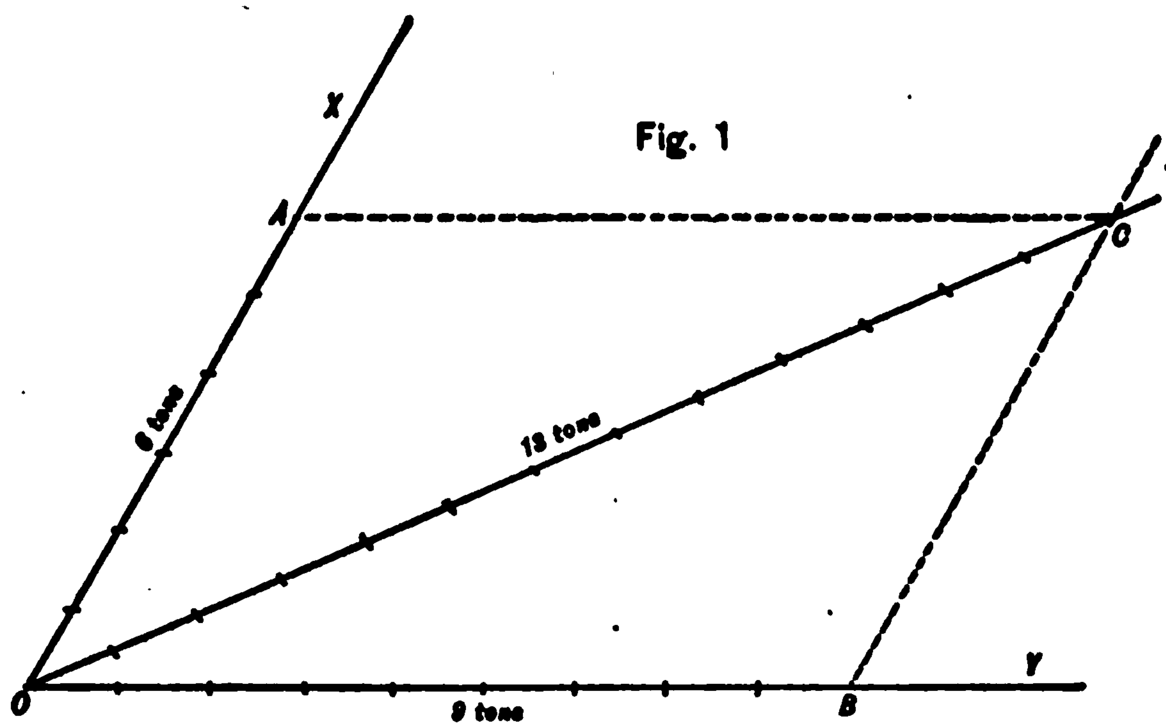


Fig. 1

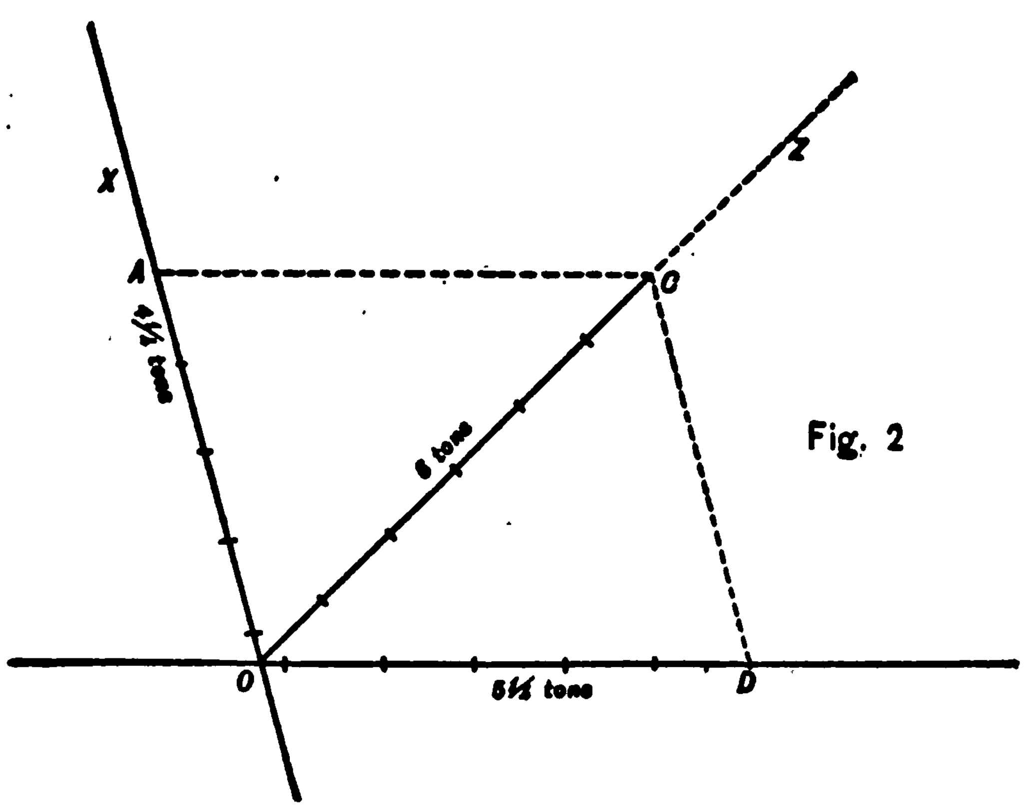


Fig. 2

THE COMPOSITION AND RESOLUTION OF FORCES.

being equal to the number of units of force to be represented. Thus a force of 5 tons may be denoted by a line five units in length;—the units being feet, inches, tenths of inches, or anything else that we like to use. The scale is merely a matter of convenience, but the same scale must of course be used in all parts of the same problem.

We proceed to illustrate the Resolution and Composition of Forces.

In Fig. 1, Plate **24**, suppose O A and O B to represent two forces acting along the lines O X and O Y, and suppose it is desired to find a single force which may replace these without change in effect upon O. We construct the parallelogram A O B C and draw the diagonal O C. This diagonal represents, in direction and in length, the desired resultant; its length being measured, of course, in the same units that have been used in laying off O A and O B. In this case, if O A = 6 tons and O B = 9 tons, O C, the resultant = 13 tons. That is to say, a force of 13 tons acting along O Z, will produce exactly the same effect as six tons acting along O X and nine tons acting along O Y. If we have to deal with three or more original forces, we may couple two of them and find a resultant, then couple this resultant with another one of the original forces and proceed as before to find the resultant of these, and so on.

It is clear that, by reversing the above process, we may resolve a single given force into two or more others acting along certain lines. Having given 13 tons acting along O Z, suppose we are called upon to find two forces which, acting along O X and O Y, shall be equivalent to this original force. As before, we construct the parallelogram A O B C. Then the sides O A and O B represent by their lengths the forces which, acting in these two directions, are equivalent to O C. O A is found to be 6 tons and O B, 9 tons. Similarly in Fig. 2, suppose we have a force denoted by the length of O C acting along O Z, and wish to resolve this along the lines O X and O Y, making angles of 45° and 60° with O Z. Constructing the parallelogram O B C A as before, we have the lengths O A = 4¼ tons, and O B = 5¼ tons, for the forces required.

Evidently, if a point is at rest, the forces acting upon it must balance each other. Consider the case illustrated in Fig. 1, Plate **25**, of a weight suspended from a boom, the heel of which

is attached to the mast while the other end is supported by a topping-lift from the masthead. The forces acting here are the downward pull of the weight, the tension on the lift, and the resistance of the boom to compression (Fig. 2, Plate **25**). As the point O remains at rest, these forces must balance each other;—that is to say, each force considered by itself must be balanced in magnitude and direction by the resultant of the other two forces. If this were not so, motion would result. Suppose we wish to find the tension on the topping-lift. We lay off O C on any convenient scale to represent the downward pull of the weight, and on O C as a diagonal, construct the parallelogram O B C A (Fig. 1, a). O A is the measure of the tension on the topping-lift, and O B that of the thrust along the boom. If the weight is 9 tons, O A is $6\frac{3}{4}$ tons and O B is $4\frac{1}{2}$ tons.

There follows from the above a simple and convenient rule for determining the relative stresses on the various parts of the system from a simple comparison of their relative lengths. The sides of the triangle O A C are parallel to the sides of the triangle formed by the mast, the boom, and the topping-lift.

These two are therefore "similar" triangles in the geometrical sense of the term, and it follows that the same relations exist between the sides of one of them as between the corresponding sides of the other; that is to say, the side O A, which represents the tension on the topping-lift, is the same proportion of O C, the downward pull of W, that the length of the topping-lift is of the length of the mast. From which we have the convenient rule expressed by the following proportion.

$$\frac{\text{Tension on Topping-lift}}{\text{Weight}} = \frac{\text{Length of Topping-lift}}{\text{Length of Mast}}.$$

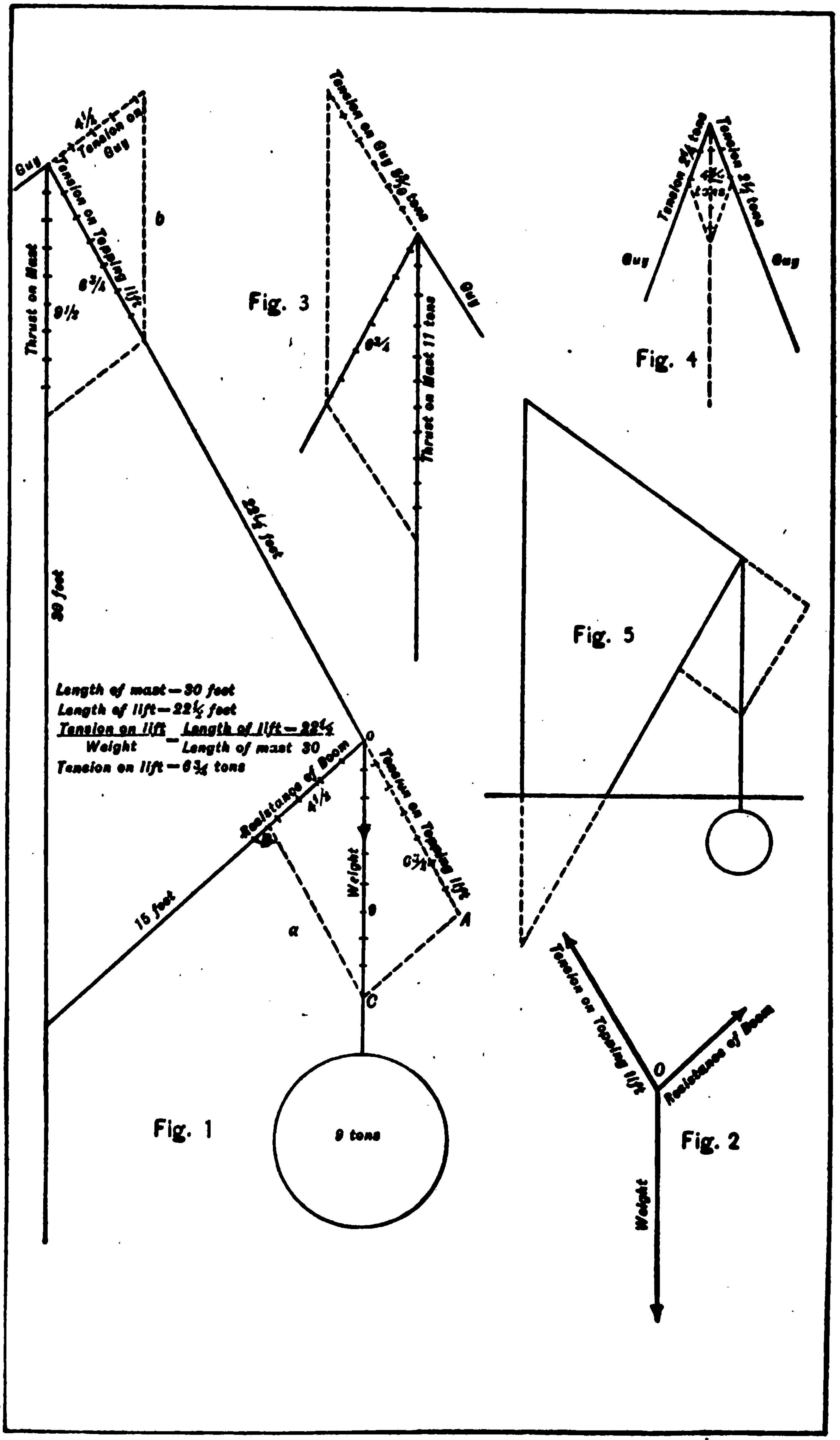
If the boom is stepped at a distance from the mast, this rule may be applied by prolonging the line of the boom until it intersects the mast, and using in calculation, the lengths given by this construction (Fig. 5, Plate **25**).

Similarly we may deduce the rule:

$$\frac{\text{Thrust on boom}}{\text{Weight}} = \frac{\text{Length of boom}}{\text{Length of mast}}$$

It will be understood that the lengths given above for mast and boom are those actually included in the triangles of Figs. 1 and 5.

Plate No. 25.



THE COMPOSITION AND RESOLUTION OF FORCES APPLIED TO A DERRICK.

This leads to a further important deduction with regard to the most favorable relation between the mast, the boom, and the topping-lift, as follows:

For a fixed length of mast and boom, we cannot change the thrust on the boom by any change in its angle; but we may vary the tension on the topping-lift within wide limits. Since this tension depends upon the length of the topping-lift, it grows less and less as the boom is topped up, becoming a minimum when the boom is as nearly vertical as it can be made. It is, at this point, very much less than the tension on O W due to the direct downward pull of the weight; but if we lower the boom toward the horizontal we presently reach an angle, depending upon the length of the boom, at which the length of the lift is equal to the length of the mast. At this point, then, the tension on the lift is equal to that along O W. If we lower still further, the tension on the lift increases beyond that on O W and may become very much in excess of it. For a given length of mast and boom, then, the more nearly vertical the boom can be used the better. If we are at liberty to vary the length of the mast and boom to attain *a given reach,* we shall find that a short boom, nearly level, gives a minimum strain on the boom and a maximum strain on the lift; while a long boom, well topped-up, gives a maximum strain on the boom and a minimum strain on the lift.

Suppose the boom is half as long as the mast. The thrust on it will be one-half the weight, no matter what the angle of the boom may be. The tension on the topping-lift will be about 1¼ times the weight when the boom is level, and rather less than ¾ of the weight when the boom is topped up to 45°.

The practical conclusion from this is that if we are called upon to rig a derrick we should consider carefully the relative trustworthiness of the materials with which we have to work. If we have a topping-lift which is abundantly strong, to be used with a boom about which we are not so sure, it is well to make the boom as short as possible and keep it nearly level. If on the other hand the boom and its fastenings are known to be safe but the topping-lift is not entirely satisfactory, we should use the full length of the boom (or choose a longer one if we have a choice) and top it up as far as possible, to give the required reach. If the reach is such that a *long boom must be used and*

kept nearly level, we have the maximum of unfavorable conditions as regards both boom and lift. In this case all that we can do is to lead the lift from a point as far up the mast as is practicable. This increases the absolute length of the lift, but decreases its relative length as compared with the mast; and, as we have seen, it is the relative and not the absolute length that determines the proportion of strain to be borne by the lift.

This case—of a long boom nearly level—is the ordinary one of a lower yard used for handling weights.

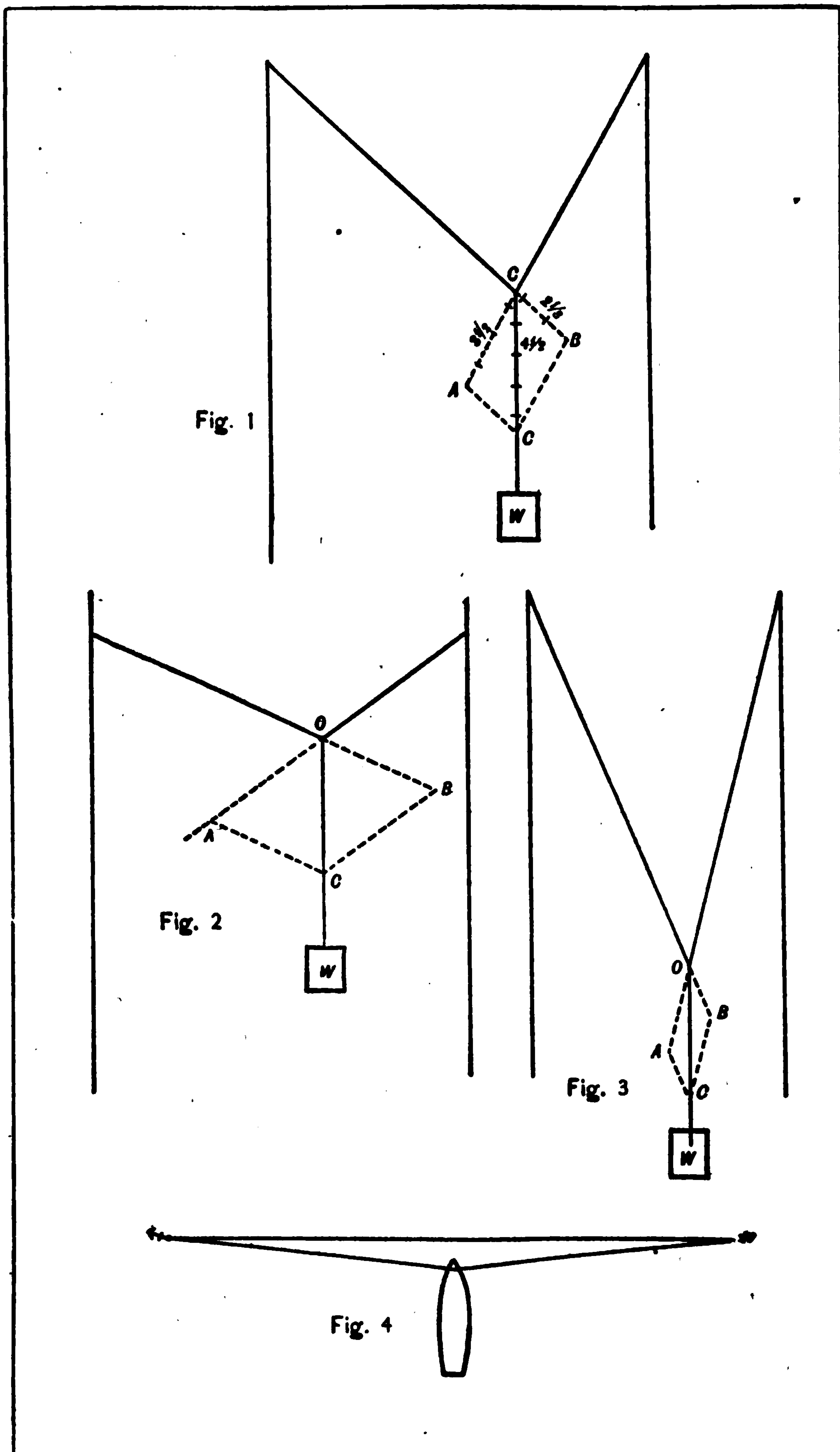
If the weight is suspended from the boom (or yard) outside or inside of the point at which the lift or burton is made fast, the situation is somewhat modified, as will be explained in connection with the Lever.

If we wish to find the tension on the guys or shrouds supporting the mast, we start with the tension on the lift, and resolve this along the lines of the guy and the mast, exactly as we have already resolved the downward pull of the weight along the line of the boom and the lift. In Fig. 1, b, Plate **25**, the tension on the guys is found by this method. In the particular case there illustrated it proves to be 4¼ tons. If we vary the lead of the guy, we shall find that, by bringing it closer to the mast, as in Fig. 3, we increase the tension on it, exactly as we do in the case of the topping-lift when we bring this down the mast and make it fast only a little distance above the heel of the boom.

If there are two guys (or shrouds) in use, we have only to resolve the tension above found for a single guy along the lines of the two which replace it, as in Fig. 4. In this particular case, assuming the angle between the guys to be 40°, we find the tension on each to be 2¼ tons.

There is an important difference between the case in which the derrick is used with a fixed elevation and that in which it is to be topped up or lowered with the weight hanging from it. In the first case, the only demand upon the parts of the topping-lift is that arising from the downward pull of the weight, this pull being resolved along the line of the topping-lift as above described. In the second case, there is added to this an important percentage due to the resistance of friction, as is explained in the Chapter on Tackles.

(See Practical Examples at the end of Chapters VI and VII.)



THE COMPOSITION AND RESOLUTION OF FORCES.
APPLIED TO A SPAN.

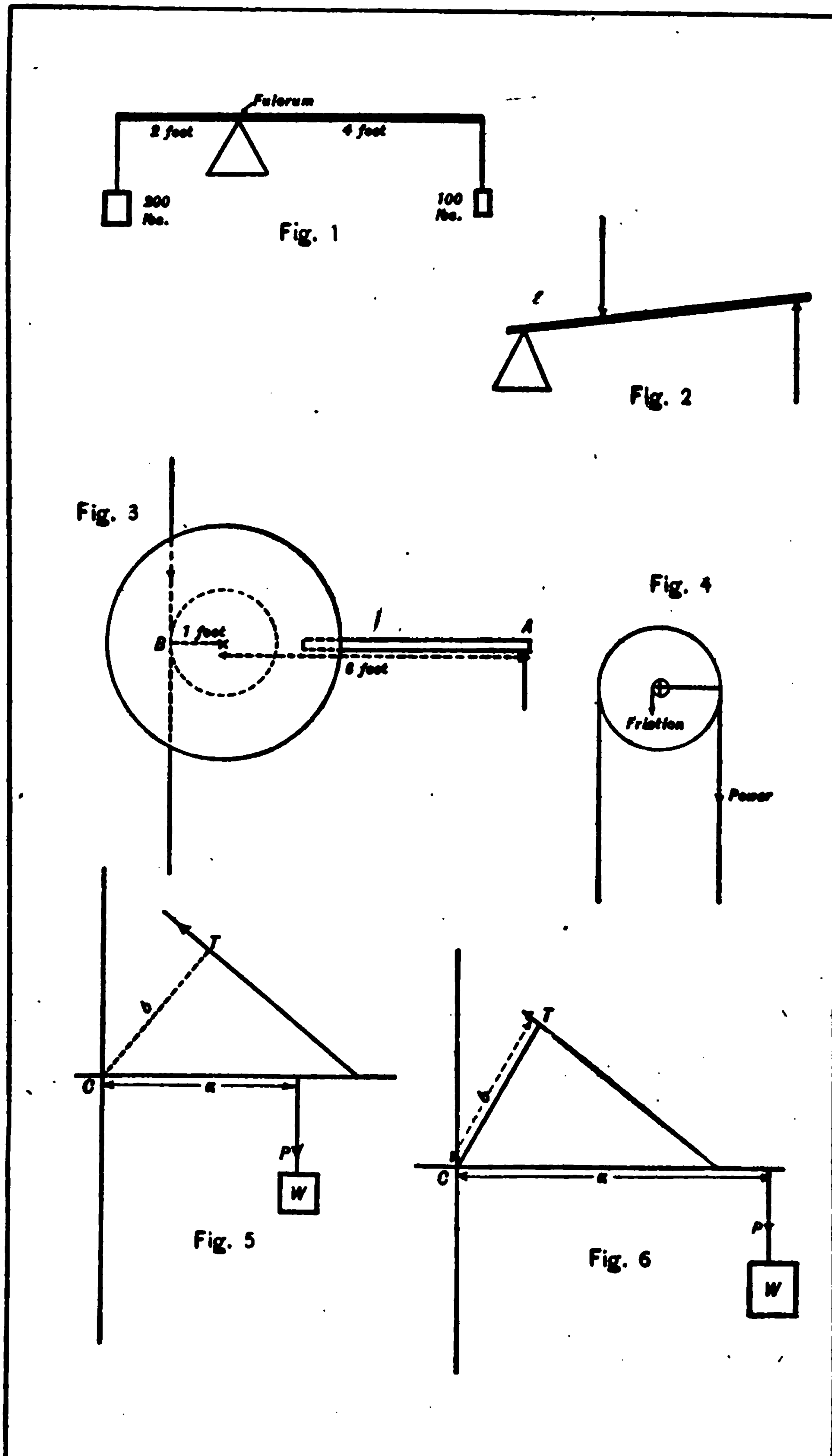
THE SPAN.

As another practical example of the resolution and composition of forces, we may consider the Span (Plate 26).

Suppose first that this is rigged between two masts for plumbing a hatch. If the two parts of the span make equal angles with the vertical, they will bear equal strains; otherwise the one which hangs more nearly vertical takes the greater strain. In Fig. 1, if the length O C represents the number of units of force in the downward pull of W, we find the tension on the two parts of the span by constructing the parallelogram of forces as in the cases already considered; O A giving the tension on one part and O B that on the other. It will be noted that if the parts of the span are opened out, increasing the angle A O B, as in Fig. 2, the parallelogram is flattened out, with a rapid increase in the length of the sides which represent tensions on the parts; whereas if they are brought together, as in Fig. 3, the tensions indicated on the parts are reduced. When the angle of the span is 120°, the tension each part is equal to the direct downward pull of the weight; or, in other words, the span is just equal in strength to the single part O W. If the angle is reduced below 120°, the tension on each part decreases, until, when they are parallel, they divide between them the total tension due to the weight;—in other words, the two parts are now twice as strong as the single part O W. On the other hand, as the parts open out beyond 120°, the essential weakness of the span becomes more and more apparent, the tension on the parts increasing enormously as the angle between them approaches 180°.

It is evident from the above that the use of a span is objectionable unless the angle between the parts can be made small; and that in any case where it is to be used, the higher up the masts the parts can be made fast, the better.

A familiar example of a span is furnished by the cables of a vessel moored and riding with an open hawse. If in Fig. 4, Plate 26, the parts of the span represent the cables of such a vessel, making an angle of 170° with each other, it can be shown that for a force of 10 tons acting along the keel line, we have a tension of 57.3 tons on each cable. In other words, two cables used in this way are only about one-sixth part as strong as one cable laid out ahead. (See Chapter on Ground Tackle.)


Fulcrum
2 feet
4 feet
200 lbs.
100 lbs.
Fig. 1
Fig. 2
Fig. 3
1 foot
B
A
Fig. 4
Friction
Power
T
b
C
a
P
W
Fig. 5
T
b
C
a
P
W
Fig. 6

THE LEVER

The Lever.

Another important principle of Mechanics which is involved in work on ship-board is that of the Lever.

A lever is a rigid bar movable about a fixed point called the "fulcrum."

It is a matter of every-day experience that two equal forces applied at equal distances from the fulcrum of a lever will balance; and that a small force applied at a considerable distance on one side will balance a greater force applied at a shorter distance on the other side. We have here illustrated, the principle of the lever; or, as it is sometimes called, the Principle of Moments; a "moment," in the mechanical sense, being the product of a force acting on a lever multiplied by the length of the arm with which it acts.

The Principle of Moments is expressed in the following statements.

1st. The tendency of a force to produce motion about an axis is measured not by the magnitude of the force alone, but by the product of the force into the distance of its line of action from the axis.

2d. If any system remains at rest, the sum of the moments tending to turn it in any direction about any axis must be equal to the sum of the moments tending to turn it in the opposite direction about the same axis.

In Fig. 1, Plate 27, the moments of the forces opposed to each other are respectively 4×100 foot-lbs. and 2×200 foot-lbs.; and as these balance, the system remains at rest.

It is by creating a difference between opposing moments that force is multiplied by means of a lever; a small force being applied with a long arm to overcome a large force acting with a short arm.

It should be noted that the forces whose moments are opposed to each other may act on opposite sides of the fulcrum, as in Fig. 1 or on the same side, as in Fig. 2.

Perhaps the most familiar example of a lever on ship-board is the old-fashioned capstan (Fig. 3), the principle of which is preserved in the winches and windlasses of modern steamers. Another example of the lever, though one not always thought of as such, is the sheave of a block turning upon a pin by the tension

of a rope passing over its periphery (Fig. 4). Here the friction between the sheave and the pin constitutes a force opposing the tension of the rope, and we have two moments as indicated in the figure. This is (in part) the reason for the rule that sheaves should be as large as is conveniently practicable.

The principle of the lever is involved in all cases where a force is applied to a rigid body at a point other than the point of support; as for example, in the case of a weight suspended from a yard or a derrick at a point inside or outside the lift or burton. In Fig. 5 the weight is hung inside the lift and the downward pull is divided between the lift and the truss. To find the tension borne by each, we must apply the principle of moments. Considering the axis of the system as at C (the truss), we have for our equation of moments $aP = bT$, where a and b are the two arms, P the downward pull of the weight, and T the tension on the lift.

If the weight is suspended outside the lift, as in Fig. 6, the equation is, as before, $aP = bT$; and since in this case a is greater than before, while P and b are unchanged, it follows that T must be greater than before. That is to say, the farther out on the yard a weight is hung, the greater the resulting tension on the lift.

THE TACKLE.

There is no mechanical appliance of greater importance than the tackle, but as this is fully treated in the next Chapter, it will be omitted here.

It is important to note that in all mechanical appliances by which power is multiplied, the gain in power is purchased by a proportional sacrifice of speed. Thus in the capstan (Plate **27**), the power applied at A is multiplied five times at B, but B moves only one fifth as fast as A. So in a tackle, as will be explained hereafter. And so in all cases where power is multiplied.

In all cases where yards, derricks, tackles, etc., are used for handling weights, it must not be overlooked that the weights of the spars, blocks, ropes, etc., are to be reckoned with in our calculations; the weight of each of these constituting a downward force acting at its individual centre of gravity.

CHAPTER IV

BLOCKS AND TACKLES.

(Plates **28** and **29**.)

§ I. BLOCKS.

A " Block," in the nautical sense, consists of a frame of wood or metal within which are fitted one or more sheaves or pulleys over which a rope may be led for convenience in applying power. If the block is properly used, it multiplies the power as explained in connection with Tackles. (§ II.)

A " made " block is built up of several pieces of wood or iron riveted or bolted together. In a " mortised " block, the frame is made of a single piece of wood mortised out to receive the sheave.

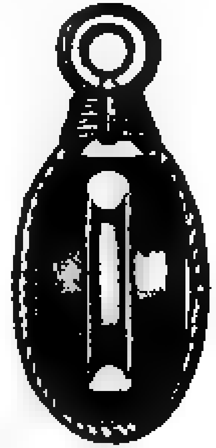
Sheaves may be of metal or of lignum-vitæ. If of the latter they are boushed with metal.

The *swallow* of the block is the space between the sheave and the frame, through which the rope passes. The side pieces of the frame are the *checks,* and the end of the block opposite the swallow is the *breech.*

A *score* is cut around the outside of the block to take the *strap,* which may be of hemp or wire-rope or of wrought iron. A hook or shackle is usually attached to the strap at one end of the block. The friction of a sheave upon the pin is an important factor in the efficiency of the block, as all power expended in overcoming this friction is wasted. For this reason blocks are often fitted with rollers or balls in the bearings for the pins. Such blocks, although in almost universal use, are commonly known as " patent-blocks."

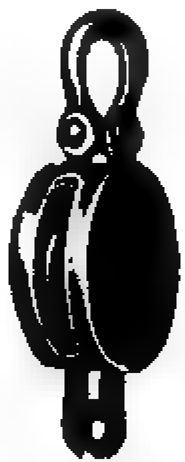
The subject of friction will be treated at considerable length under the head of tackles, where it will be shown that a large sheave is essential for efficiency, and that the swallow should be large enough to prevent the rope from touching any part of the block except the sheave.

Special types of blocks are made for use with wire-rope.



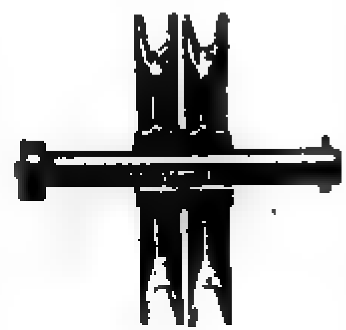
Wooden Blocks, Rope—Strapped

Steel Blocks for Wire Rope.



Wooden Block Iron—Strapped.

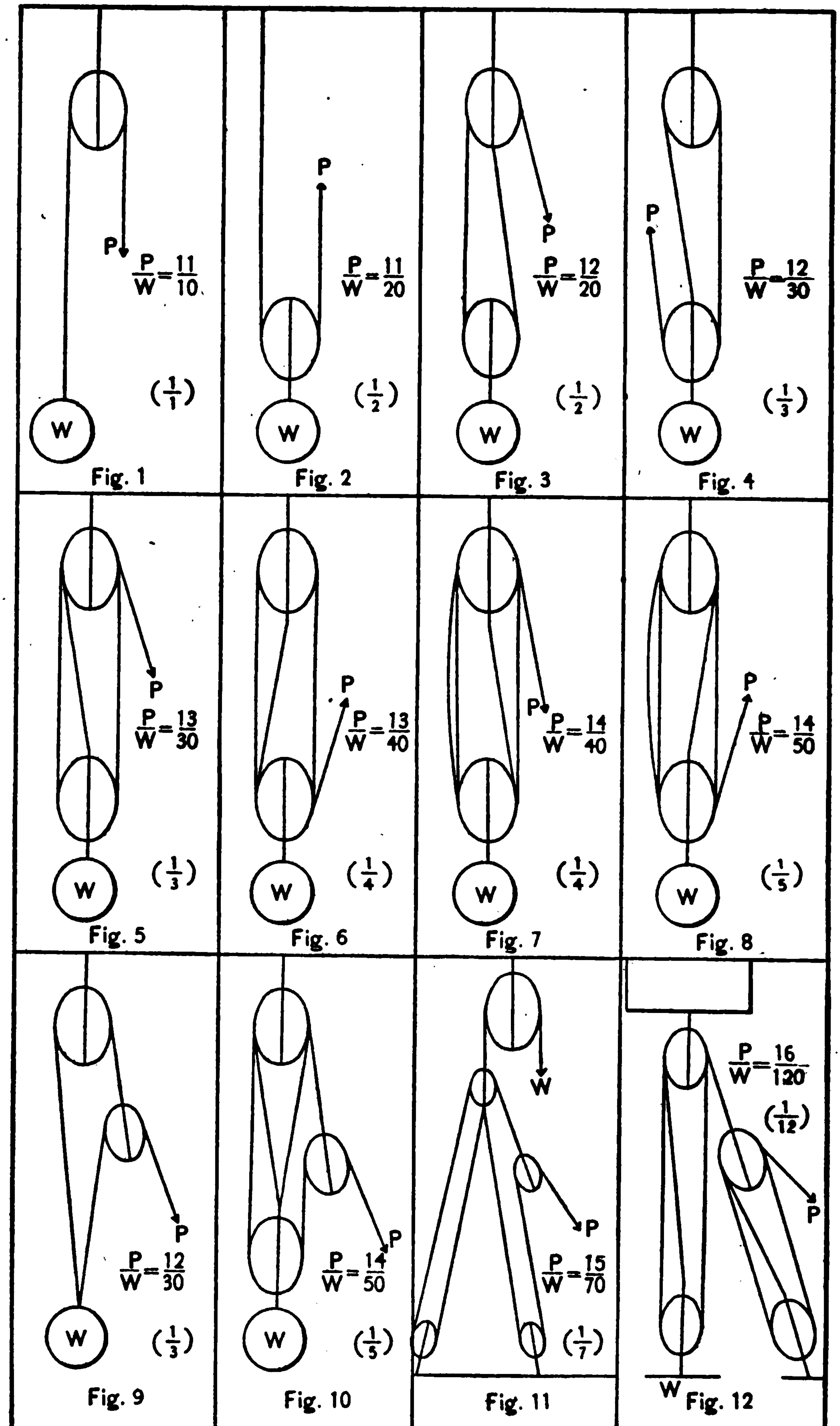
Gin Block.



Sheave and Axle.

BLOCKS.

Plate No. 29.



TACKLES

Note:–
The ratios given for power to weight are based upon the allowance for friction described in Chapter VI.
(Figures in brackets show the theoretical ratio of power to weight, obtained by disregarding friction.)

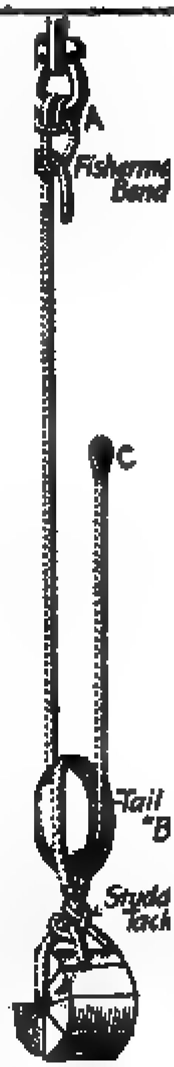


Fig. 1.
Single Whip.

Fig. 2.
A Runner or
Single Whip Rever

Purchase.

Fig. 4.
Luff Tackle.

Fig. 5.
Cask Slung with the End
of a Single Whip.

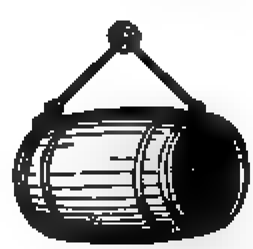


Fig 6.
Cask Slung with Can Hooks.

TACKLES IN USE.

Plate No. 31.

Fig. 2.

TACKLES IN USE.

Fig. 1.
Two-Fold Tackle.

Fig. 3.
Double Spanish Burton.

TACKLES IN USE.

Blocks take their names from the purposes for which they are used, the places which they occupy, or from some peculiarity in their shape or construction. They are further designated as single, double, treble, and four-fold, according to the number of their sheaves.

Various types of blocks are illustrated in Plate **28.** Rope-strapped blocks are shown in connection with Tackles in Plates **30. 31** and **32.**

Snatch-blocks are single iron-bound blocks, hooking to bolts on the deck to give a fair lead for boat-falls, topsail halliards, etc. The frame and strap are cut and hinged in such a way as to admit of " snatching " the fall, on the bight.

Gin-blocks, or *gins,* are iron pulleys (single) of large diameter, mounted in skeleton frames also of iron. Used chiefly for hoisting cargo, commonly with a wire-rope pendant.

Secret-blocks have the sheave entirely enclosed except that holes are left on each side for reeving the rope. They are used for clew-lines and clew-garnets of topsails and courses to prevent the fouling of the block by reef-points.

Strapping Blocks. Rope is very little used on modern ships for strapping blocks, but wire-rope may sometimes be used with advantage, as being more reliable for a given calculated strength, than the iron work usually fitted. There is an especial advantage in this where very heavy weights are to be dealt with. For such work, a strap fitted with long lashing-eyes may be recommended.

As to the strength of blocks, see § IV of this chapter.

§ II. TACKLES.

A combination of ropes and blocks for the purpose of multiplying power constitutes a tackle.

If we reeve a rope through a fixed block and apply power at one end to lift a weight at the other, we have a " Single whip," which is usually classed as a tackle, but gives no gain of power. If the block instead of being fixed is attached to the weight to be lifted, and one end of the rope made fast while power is applied to the other end, we have a tackle proper in its simplest form. Here (disregarding friction) the power applied to the hauling part is doubled at the movable block because it is transmitted around the sheave and so acts along both parts upon the mass to be moved. In the same way, the tension may be trans-

mitted around any number of sheaves with a gain of power at each sheave of the movable block.

It should be noted that the tension is transmitted around the sheave of a fixed block exactly as it is around that of a movable one; but with no other effect in the case of the fixed block than to increase the pull upon the block and its supports. This point is often overlooked, but it is very important. If a weight of 100 lbs. is hanging from a yard-arm by a single whip *with both ends made fast to the weight,* the pull on the yard-arm is 100 lbs. If now we leave the weight hanging by one part of the whip and man the other part, or hold on to it, or make it fast on board, the pull on the yard is 200 lbs. The same point comes in with all purchases, but with less proportionate effect. If we have to find the tension on a yard or derrick to which a fixed block is made fast, we must add the tension on the hauling part to the direct downward pull of the weight.

Evidently, if we could neglect friction, we should have the simple rule that the power at the movable block is to the power on the hauling part, as the number of parts at the movable block is to one; but in practice this rule is modified by the work absorbed each time the rope passes over a sheave. This work is accounted for principally by the friction of the sheave upon its pin; but the bending of the rope around the sheave with the accompanying deformation of the fibres counts for something, and in wire-rope may be an important part of the total loss.

The stiffer the rope, the greater the loss from this source.

It results from this loss of power in passing around the sheaves that the tension on the successive parts of the fall grows less and less as we advance from the hauling toward the standing part and that the effective power of the tackle must be found by subtracting from the theoretical power, the proportion wastefully absorbed as above described. This proportion varies within wide limits; but it is always larger than is commonly supposed, increasing with the speed of working and with a decrease in the diameter of the sheave. It is reduced by low speed, and by the use of flexible rope and well-made patent blocks, having sheaves of large diameter as compared with the ropes they are to carry and kept in good order by frequent overhauling. If the rope touches the side of the block there is introduced a wholly unnecessary amount of friction with corresponding waste of power.

A small sheave, in addition to wasting power and increasing the wear upon the rope, introduces a direct and often fatal source of weakness by the difference in tension which it puts upon the successive layers of fibre from the inside to the outside of the bend, the outer layers being sub-

jected to extreme tension while the inner ones are actually compressed. The result is that the outer layers give way and are followed by the others in succession toward the inside. This is the explanation also of the weakness in a sharp nip of any kind, whether due to a splice, a hitch, a bad lead or a bend around a pin or post.

Observe that whereas *in hoisting,* the maximum tension comes on the hauling part, *in lowering,* it comes on the standing part.

If the system is at rest, friction will tend to keep it at rest and will reduce the power needed at either end to maintain equilibrium. Thus if we have a mass of 800 lbs. hanging from the lower block of a two-fold purchase, we should require 200 lbs. on the hauling part to maintain equilibrium if there were no friction; but since in practice there is and must be friction, we shall be able to prevent motion by much less than 200 lbs. As an extreme case, we may imagine the friction so great that nothing is needed on the hauling part to prevent the lower block from moving;—the weight of 800 lbs. not being sufficient to "overhaul" the tackle. Similarly a mass of 200 lbs. on the hauling part may be held at rest by much less than 800 lbs. on the lower block, the friction acting as before to prevent motion.

If we attempt, as a matter of convenience, to assign *an approximate numerical value to the loss by friction,* we shall find it convenient to represent this loss as a percentage added to the load; and experience shows that it is a safe general rule to increase the load by 10 per cent for each sheave over which the fall leads and then to consider that this increased load is being lifted by a frictionless purchase. Accordingly, to find the power required on the hauling part, or (what is the same thing) the maximum tension on the rope, we add the percentage for friction as above, and divide by the number of parts at the movable block. (See § IV.)

No attempt is made, in the above "Rule-of-Thumb," to take account of variations in speed due to variations in power applied, or of the fact that friction increases with the speed. The rule is for average working conditions, and includes a sufficient margin of safety to cover all practical cases.

It will be clear from the preceding that much power is wasted where the hauling part of a purchase is taken through an extra (fixed) sheave merely to give a fair lead. A familiar case of this is that in which a fall leading from aloft is taken through a block on deck to be manned or led to a winch. Such leads are

often unavoidable; and even where not so, the gain in convenience may more than offset the loss of power; but it must not be forgotten that this loss of power is considerable. The same reasoning applies to an unnecessary sheave in the fixed block of a purchase, which has of course the same effect as an unnecessary sheave anywhere else.

If one tackle is attached to the hauling part of another, the power of the combination is the product of the powers of the tackles composing it.

It is important to observe that in tackles as in all other mechanical appliances, "*what is gained in power is lost in speed.*" This is clearly brought out by a comparison of Figs. 1 and 2 of Plate **29**. In Fig. 1, a *single whip*, if the hauling part moves through one foot, the weight at the other end moves through the same distance. Both space and power are equal at the two ends of the rope. In Fig. 2, a *runner*, the power is doubled at the block, but the block moves through only half the distance moved by the hauling part. And so at every sheave of a movable block. If the power is multiplied six times, as by a three-fold block, the hauling part must move through six feet to move the block one foot. This may be a very important point where space is limited.

Tackles are of value not only as multiplying power but as applying the power more smoothly and uniformly. So, too, in easing away, they prevent the surging which is almost unavoidable with a single part, and at the same time make it possible to lower more slowly and with much more exactness; since, as has been explained, the motion at the block of a purchase is only a fractional part of what is given on the fall. The greater the number of parts to the tackle, the greater the gain in this respect as well as in the power.

For heavy work with a three- or four-fold purchase, the fall should be rove with the hauling part leading from the middle sheaves of the blocks instead of from the outer ones. This involves a turn in the parts, but reduces the chance of slewing the blocks in their straps. For light purchases, it is a common practice to make the standing part fast to a becket worked into the strap. This will not answer for heavy work. If the standing part is to be made fast to the block, it should be taken around and secured between the block and the hook (Fig. 1, Plate **32**). It is a still better plan to make it fast to the weight to be lifted,

close alongside the block, instead of to the block itself. The hauling part of a tackle should be kept as nearly as possible parallel to the other parts. A divergence from this line means a loss of power.

As the power of a tackle depends upon the number of parts at the movable block, we have the rule that whenever circumstances permit, the block having the greater number of parts—or in other words, the block from which the hauling part leads—should be attached to the weight to be moved. This rule is often disregarded because it is usually impracticable to take the hauling part from the lower block directly to the winch; and the most natural way of giving it a lead from the derrick-head is to place there the block of the tackle from which this part leads. A better plan is to let the hauling part come from the lower block, and to take it up through an independent leading block at the derrick-head; thus preserving the full power of the tackle. In many cases it is necessary to use still another leader at the heel of the derrick.

§ III.

Tackles may be designated either according to the number of sheaves in their blocks; as, single, double, three-fold, etc.; or according to the purpose for which they are used; as, Yard-tackles, Stay-tackles, Fore-and-aft-tackles, etc. Still other designations, not so easily accounted for, are luff-tackles, gun-tackles, Spanish-burtons, etc.

Tackles are almost invariably rove of manila rope.

Plate **29** shows diagrammatically various forms of tackles with the theoretical gain in power due to each and the approximate actual gain when friction is taken into account. Plates **30**, **31** and **32** illustrate certain common applications of tackles on shipboard.

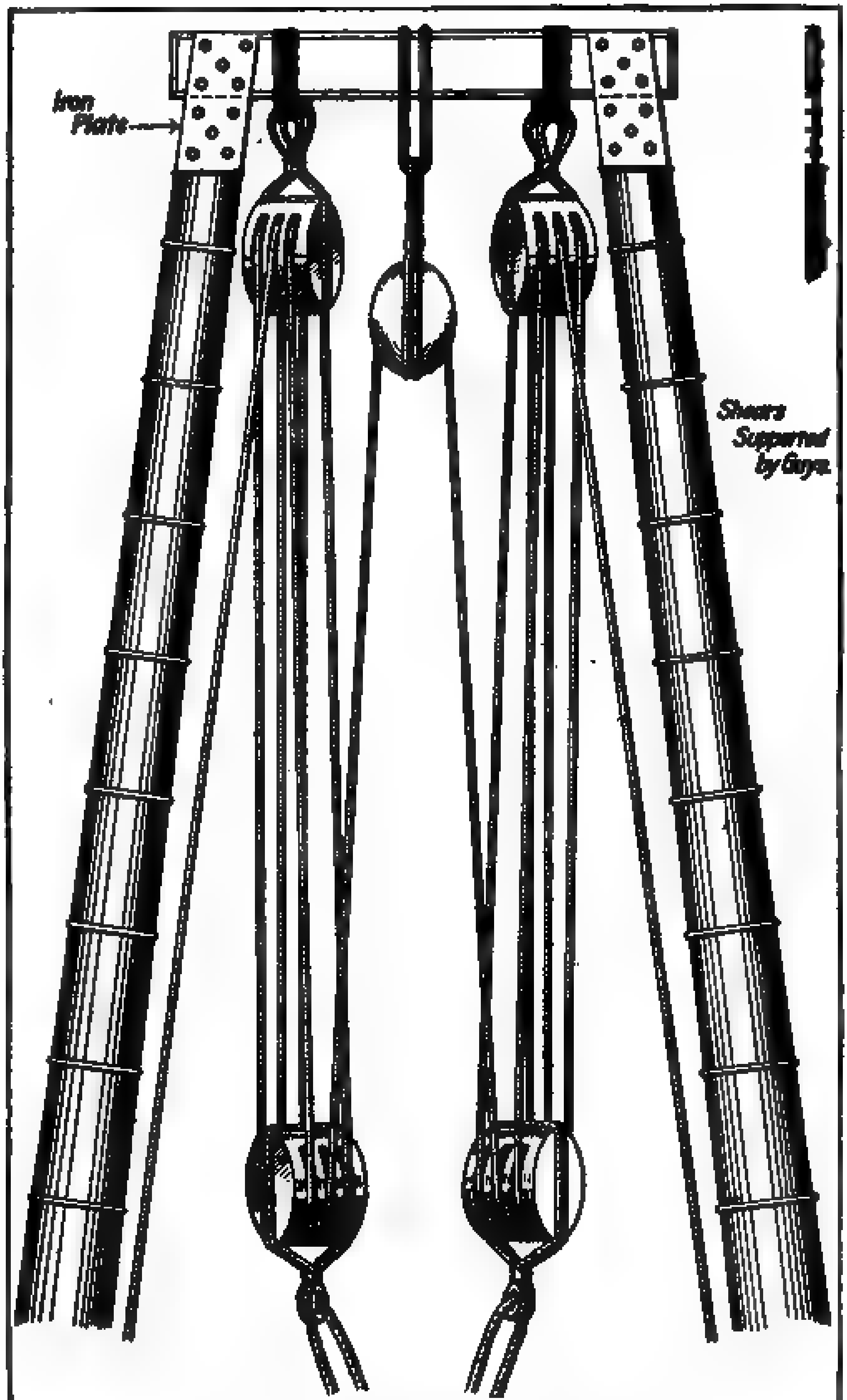
A *Single-whip* (Fig. 1, Plate **29**). A single block, fixed.

A *Runner* (Fig. 2, Plate **29**). A single block, movable.

A *Whip and Runner* would be a whip hooking to the hauling part of a runner.

A *Gun-tackle* (Figs. 3 and 4, Plate **29**). Two single-blocks.

A *Luff* (Figs. 5 and 6, Plate **29**). A single and double-block. Sometimes called a "watch-tackle."



SHEARS WITH DOUBLE THREE-FOLD PURCHASE FOR HANDLING HEAVY WEIGHT.

A *Two-fold Purchase* (Figs. 7 and 8, Plate **29**). Two double-blocks.

A *Three-fold Purchase,* of two treble-blocks, is about the heaviest purchase used on ship-board.

The above are all the purchases in common use. It will be noted that in all cases where the two blocks of a purchase are alike, the hauling part leads from the block to which the standing part makes fast, while in cases where one block has an extra sheave, the hauling part leads from this block and the standing part from the other. To get the full power of any of the purchases, the block from which the hauling part is led must be secured to the object to be moved.

A *Spanish Burton* (Fig. 9, Plate **29**) Two single-blocks, one fixed, the other movable, with a bight of the fall secured to the object moved.

A *Double Spanish Burton* (Fig. 10, Plate **29**). A fixed double and two movable single-blocks, which are made fast to the object to be moved.

A *Bell's Purchase* (Fig. 11, Plate **29**). Four single-blocks, two fixed and two movable, with a bight of the fall stopped to one of the movable blocks.

A *Luff upon Luff* (Fig. 12, Plate **29**). The double-block of one luff hooking to the hauling part of another.

Plate **33** shows a special purchase which may be used for very heavy weights. The tension of the various parts of the fall is partially equalized, by applying the power to both ends.

A *Deck-Tackle* is a heavy purchase, usually two fold, used in handling ground-tackle, mooring ship, and, generally, for heavy work about the decks.

Pendant-Tackles are heavy two-fold purchases kept hooked to the lower pendants and designed primarily for setting up lower shrouds or for steadying the masts if the rigging becomes slack. They are also used, like deck-tackles for general work about the decks.

Yard-Tackles are used on the lower yard-arms for hoisting in provisions, stores, etc. Any tackle used on the yard is for the time being a "yard-tackle" but the term is applied in a more specific way to certain rather heavy two-fold purchases kept for handling weights too heavy for a "water-whip."

Duplex Purchase.

Differential Purchase

Parbuckling a Spar on Board Ship.

DIFFERENTIAL PURCHASES — PARBUCKLING

Stay-Tackles are hooked to the collar of the lower stay or some other point aloft where they plumb the deck nearly amidships, for hauling in and landing on deck articles hoisted by the yard-tackle; or, conversely, for lifting articles to be hauled out and lowered over the side by the yard-tackle.

Fish-Tackles are heavy two-fold or three-fold purchases used for getting the anchor on the bow. They hook at the head of the fish davit and to the balancing-link on the shank of the anchor.

Top-burtons are tackles hooked to the topmast pendants and used for setting up rigging, for securing lower yards when handling heavy weights, and for other purposes requiring a tackle from aloft. They are usually rove as luffs, with a fall of sufficient length to be led out on deck when the lower blocks are also on deck.

Water-whips are gun-tackle purchases used as yard-tackles for hoisting in moderate weights (Fig. 1, Plate **31**).

A *Sail-Tackle* is a tackle used for sending a topsail aloft for bending. A top-burton is generally used for this (Fig. 3, Plate **31**).

Relieving-Tackles are used to assist or replace the tiller ropes in steering. One block hooks to the tiller, the other to the ship's side.

Stock- and Bill-Tackles are used in getting the anchors on and off the bows in old-fashioned ships. They hook to straps on the stock and bill of the anchor respectively, and lead across the deck.

Thwartship-Tackles are used on the heads of boat-davits for rigging in and out. In a more general sense the term is applied to any tackle leading across the deck.

Jiggers are light tackles used for miscellaneous work about the deck. They are commonly rove as luffs.

Hatch-Tackles are used at hatches for hoisting and lowering stores.

Differential and Duplex Purchases.

In a *differential purchase* (Plate **34**), an endless rope is taken over two sheaves of slightly different diameters which are keyed to the same shaft and revolve together. A movable block to which a weight may be attached is hung in the bight of the endless rope. If power is applied to one of the parts leading from the larger sheave, the rope is unwound from the sheave, but is at the same time wound up on the slightly smaller sheave

Fig. 3

Fig. 2

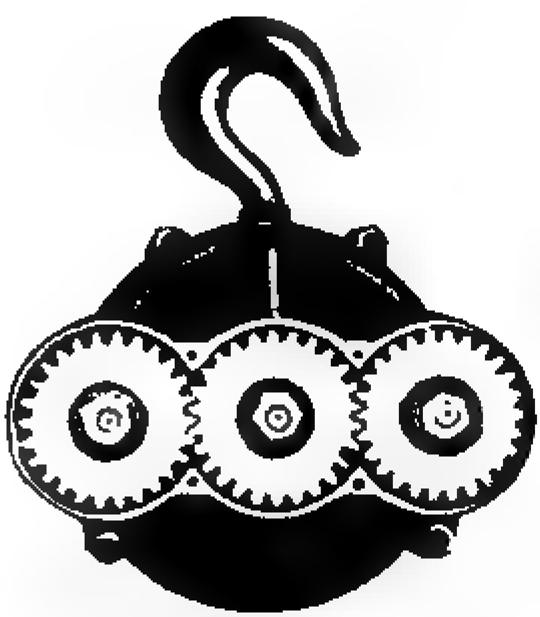


Fig 1.

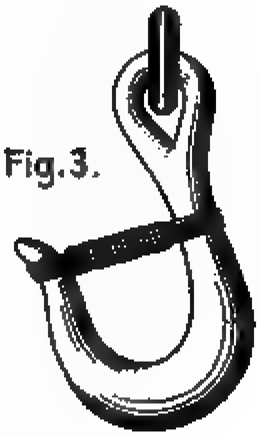
Fig. 4.

"CYCLONE" CHAIN HOIST.

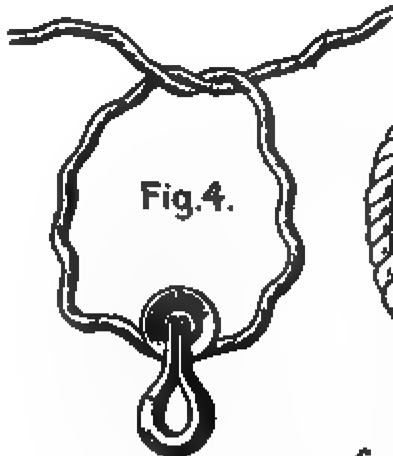
Fig.2

Strap on a Rope.
(For Hooking a Tackle.)

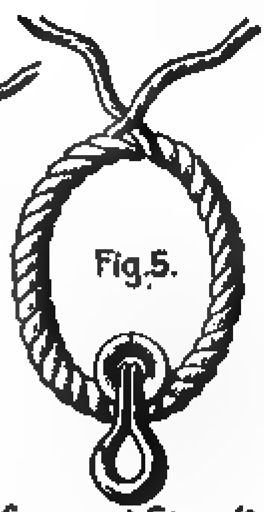
Fig. 3.



Mouse a Hook.



Grommet Strap (1.)



Grommet Strap (2

A STOPPER ON A ROPE, HOOKING A TACKLE, ETC.

alongside. Thus the change in the length of the bight which carries the movable block is very slight, for a great distance moved by the hauling part. By a simple mathematical demonstration, which would be out of place here, it can be shown that the ratio of the power applied, to the power on the movable block, is equal to the difference in the diameter of the sheaves of the fixed block divided by the larger diameter.

A *Duplex Purchase* (frequently called a Differential) is shown in Plate 34. It consists of two wheels at right angles to each other, one of which has a cogged rim engaging a series of cams on the face of the other wheel. The details are made clear by the figure. The power here may be made almost anything that is desired, by proper design of the cams and gearing. In any given case it may be determined theoretically (without friction) from the ratio of the distance moved by the power to that moved by the weight.

Still another type of patent pulley is illustrated in Plate 35. This type is much used in the Navy. Its working is as follows:

The lift wheel, that is the sprocket wheel which carries the lift chain, is cast in one piece with the spur-wheel that drives it. (Fig. 2.) This double wheel turns freely upon a hollow shaft rigidly supported at both ends in the frame. The spur-wheel is encircled by a yoke having internal teeth meshing into the spur-wheel teeth and driven with a gyrating movement about it by two eccentrics placed diametrically opposite (Fig. 3). The hand wheel shaft passes through the hollow main shaft, carrying at the further end a pinion which drives two spur-wheels, one on each of the two eccentric shafts (Fig. 4).

The number of the teeth in the spur-wheel divided by the difference between the number of the spur-wheel teeth and the number of the internal teeth of the yoke equals the number of revolutions of the eccentric necessary to turn the lift wheel once. (In the one-ton size, the spur-wheel has twenty-one teeth, the yoke twenty-four internal teeth, and the eccentrics turn seven times to each revolution of the lift wheel.) The eccentric shafts have bearings at both ends and roller bushed connection with the yoke.

The friction loss of this movement is so slight (the efficiency is about 80 per cent) that it has been found practicable to gear the hoists to a very high speed without increasing the hand wheel pull above that of other slower hoists.

The automatic brake permits the spinning of the hand wheel in either direction when there is no load, locks the load with perfect safety, and yet permits its free lowering by a very slight reverse pull on the hand chain.

§ IV. STRENGTH OF ROPES, BLOCKS AND TACKLES, ETC.

When definite information is at hand with regard to the strength of the rope in question, it should of course be utilized. In the absence of such definite information, the following rules are convenient and safe:

B = Breaking stress (lbs. or tons).
L = Safe load.
C = Circumference (inches).
D = Diameter (inches).

Rule 1. Strength of manila or hemp.

$$B = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

$$L = \frac{C^2}{15} \text{ tons} = C^2 \times 150 \text{ lbs.}$$

NOTE.—For new rope, to be used once, or only occasionally, we may use $L = \frac{C^2}{10}$ tons.

Rule 2. Strength of coir.

B and L have one-fourth of values given above for manila.

Rule 3. Strength of wire.

$$B = C^2 \times 2.5 \text{ tons} = C^2 \times 5600 \text{ lbs.}$$

$$L = \frac{C^2}{2.5} \text{ tons} = C^2 \times 900 \text{ lbs.}$$

NOTES.—(1) Observe that the working load for wire is the same as the breaking stress for manila.

(2) For new rope, to be used only occasionally and under fairly good conditions, we may use $L = \frac{C^2}{1.5}$ tons.

(3) The above rules for wire are for Type 4 (Plate 12). "Towing and Running Ropes." For the stronger types (1, 2, 3, 5) we may add 10 per cent to the working load as given by these Rules.

Rule 4. Strength of blocks.

It may generally be assumed that the safe load for a well-made *block* is in excess of that of any hemp or manila rope that it will reeve. This, however, is not always true of the *hook,* which is

almost invariably the weakest part, and often gives way under strains for which the block is otherwise amply strong. The strength of the hook is therefore the measure of the strength of the block. The difficulty here comes from the tendency of the hook to open out;—a tendency which should be guarded against, in heavy work, by careful "mousing" of the hook—preferably by an iron link.

For heavy work, *shackles* are fitted to blocks in place of hooks and are very much to be preferred, as will be apparent from the rules and tables which follow.

(a) *Hooks.*

D = Diameter at back of hook.

$L = \frac{2}{3} D^2$ tons.

(b) *Shackles.*

D = Diameter at sides.

$L = 3 D^2$ tons.

NOTE.—For a given diameter of material, a shackle is approximately 5 times as strong as a hook.

The following table gives the results of practical tests made at the Watertown Arsenal. The hooks and shackles tested were of the ordinary commercial form. The diameter given is that of the metal at the back of the hook and the sides of the shackle.

TEST OF HOOKS.

Diameter of metal.	Broke at	Remarks.
½ inch	2,885 lbs.	Hook partly straightened, then fractured across the back.
¾ "	4,180 "	
1 "	10,315 "	
1¼ "	14,510 "	
1½ "	20,940 "	
1¾ "	27,420 "	
2 "	38,100 "	
2½ "	55,880 "	

TEST OF SHACKLES.

Diameter of metal.	Broke at	Remarks.
¾ inch	20,700 lbs.	Eye of shackle parted.
⅞ "	38,100 "	" " "
1 "	51,900 "	" " "
1¼ "	75,200 "	" " "
1½ "	119,980 "	" " "
1¾ "	146,400 "	Sheared shackle-pin.
2 "	196,600 "	Eye of shackle parted.
2½ "	210,400 "	" " "

Rule 5. To find the size of manila rope to lift a given load (in tons).

For Rule 1, above, we have

$$C \text{ (inches)} = \sqrt{15 \times L \text{ (tons)}}.$$

Hence, multiply the load *in tons* by 15 and take the square root of the product for the circumference of the rope in inches.

Rule 6. To find the size of wire-rope to lift a given load.

For Rule 3, above, we have

$$C \text{ (inches)} = \sqrt{2.5 \times L} \text{ (tons)}.$$

Hence, multiply the load in tons by 2.5 and take the square root of the product for the circumference of the rope in inches.

Rule 7. To find the size of rope when rove as a tackle to lift a given weight.

Add to the weight one-tenth of its value for every sheave to be used in hoisting. This gives the total resistance, including friction. Divide this by the number of parts at the movable block, for the maximum tension on the fall. Reeve the fall, of a size to stand this tension as a safe working load.

EXAMPLE:

To lift 10 tons with a three-fold purchase, the fall of which, coming from the upper block, is taken through an extra sheave on deck for a fair lead. Required the size of fall needed.

Total resistance, including friction $= 10 + 7 \times \frac{10}{10} = 17$ tons.

Maximum tension on fall $= \frac{17}{6} = 2.8$ tons.

Size of fall (Rule 2) $= \sqrt{15 \times 2.8} = 6\frac{1}{2}$ inches (nearly)

Rule 8. To find the weight which a given purchase will lift with safety.

Find the safe-working load for the rope to be used (Rule 1). Multiply this by the number of parts at the movable block. This gives the total resistance including friction.

Multiply the total resistance by 10 and divide by 10+the number of sheaves used. The result is the weight that may be lifted.

EXAMPLE:

To find the weight which may be lifted by a fall of 6½-inch manila rove as a three-fold purchase, the fall of which leads from the upper block through an extra leader on deck.

Safe-working load, $\frac{6.5^2}{15} = 2.9$ tons.

Total resistance, including friction, $6 \times 2.9 = 17.4$ tons.

Weight to be lifted, $\frac{17.4 \times 10}{10+7} = \frac{174}{17} = 10.2$ tons.

Rule 9. To find the strength of a spar to resist compression (derrick or shears).

T = Safe thrust in tons.
R = Radius of spar in inches.
L = Length of spar in feet.

$$T = \frac{4R^4}{L^2}.$$

NOTE.—The multiplier *4* in this formula is safe for all ordinary kinds of wood. For very strong woods, like oak, mahogany, etc., it could be increased 50 per cent without danger.

EXAMPLE:

To find safe thrust for a spar 10 inches in diameter, of fir, 17 feet long.

$$T = \frac{4 \times 5^4}{17^2} = 8.6 \text{ tons.}$$

NOTES.—Rule 5, above, gives an unnecessarily large factor of safety for the stronger types of wire, but it is convenient and safe.

A well-made splice weakens either manila or wire by from 5% to 10%.

A sharp nip may weaken manila or wire by from 25% to 50%.

Manila deteriorates rapidly if stowed away wet, or if exposed, either wet or dry, to continued high temperature.

Wire-rope should be discarded when its outer wires are worn down to one-half their original diameter.

The strength of two ropes of different sizes is proportional to the *squares* of the circumferences. Thus a 2-inch rope is to a 3-inch as 4 to 9.

As a working rule, wire-rope is 6 times as strong as manila of the same size.

In cases where a load is applied suddenly, with a blow or a jerk, its effect is doubled, and this should be allowed for in calculating the size of rope required.

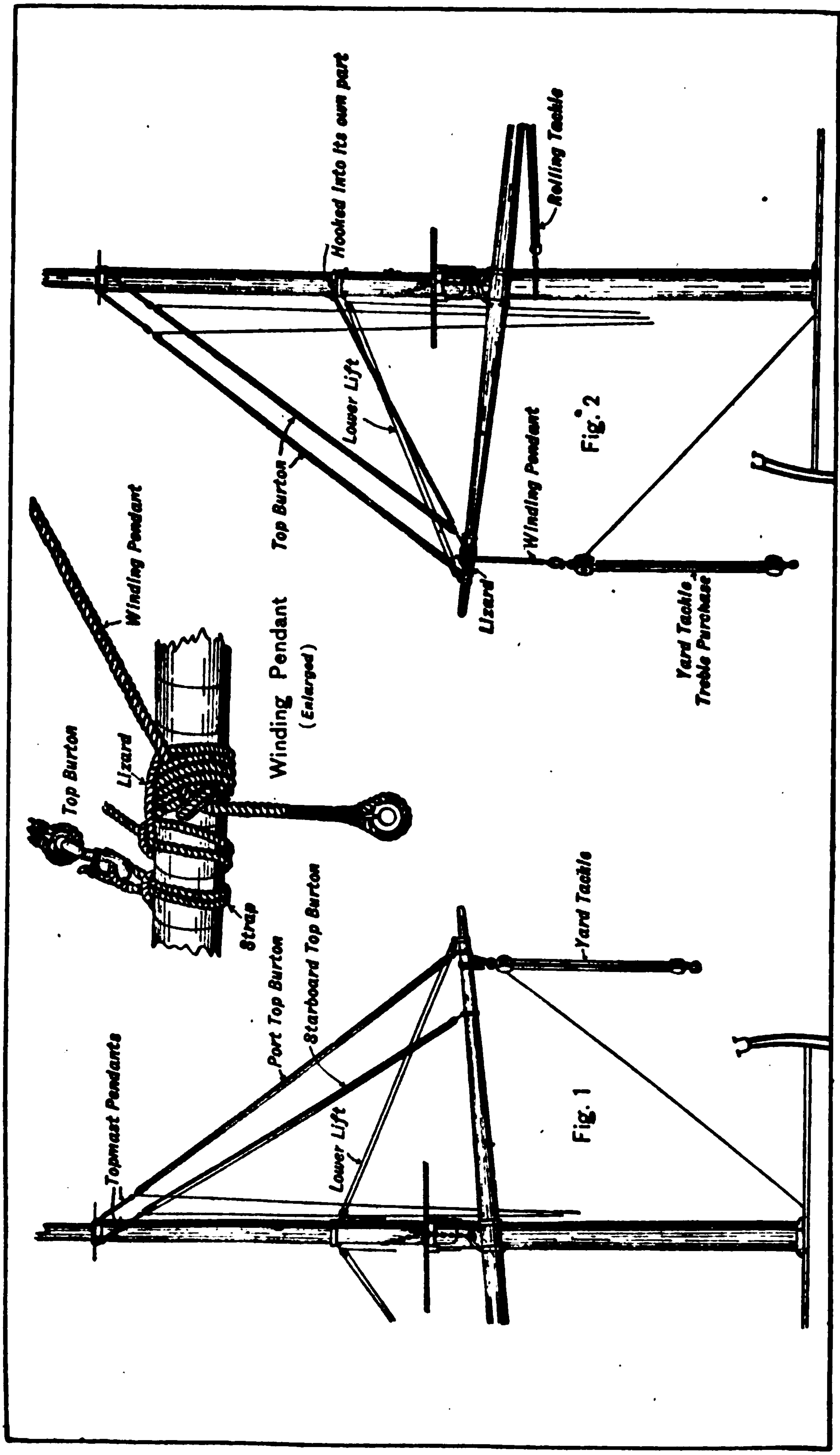
CHAPTER V.

HANDLING HEAVY WEIGHTS.

Where masts and yards are available, as in sailing ships and steamers with auxiliary sail power, the problem of handling ordinary weights presents no great difficulty. The lower yards are used as derricks, with suitable support from the mast by lifts and burtons. The principles which govern the rigging of these are identical with those discussed in Chapter III; and the practical details are shown in Plate **37**.

For moderate weights—not exceeding half a ton—a lower yard supported by the lift and one or two top-burtons as in Fig. 1, Plate **37**, gives ample security. It will be noted that the purchase is hooked midway between the burtons. With a somewhat greater weight, the yard, while supported as before, is relieved of much of the weight by a "winding" pendant from the topmast, just above the lower cap, hauled out to the yard-arm by a lizard or a tackle (Fig. 2, Plate **37**). The use of a tackle has the advantage over a lizard that it admits of easing away to plumb a hatch or any other point at which it may be desired to land the weight; thus doing away with the necessity for a "stay-tackle." The principle here illustrated is of very general application in handling weights.

Where several purchases are used to support the yard, it is important that they should divide the work as equally as possible. It will be understood from what has been said in Chapter III that they cannot divide the strains exactly unless they have identical leads; but they can be made to act together, each bearing its proper proportion of the total strain, *unless the yard is to be swung with the weight hanging from it.* This should be avoided if possible, and if it is to be done it should be clearly recognized that there is no hope of keeping anything like an equal strain on a number of purchases hooked at different points and leading off at different angles. Whatever support the yard is to have should in this case be concentrated at a single point and if possible in a single tackle. A good pendant-tackle from the topmast head hooking to a strap close to that of the yard-



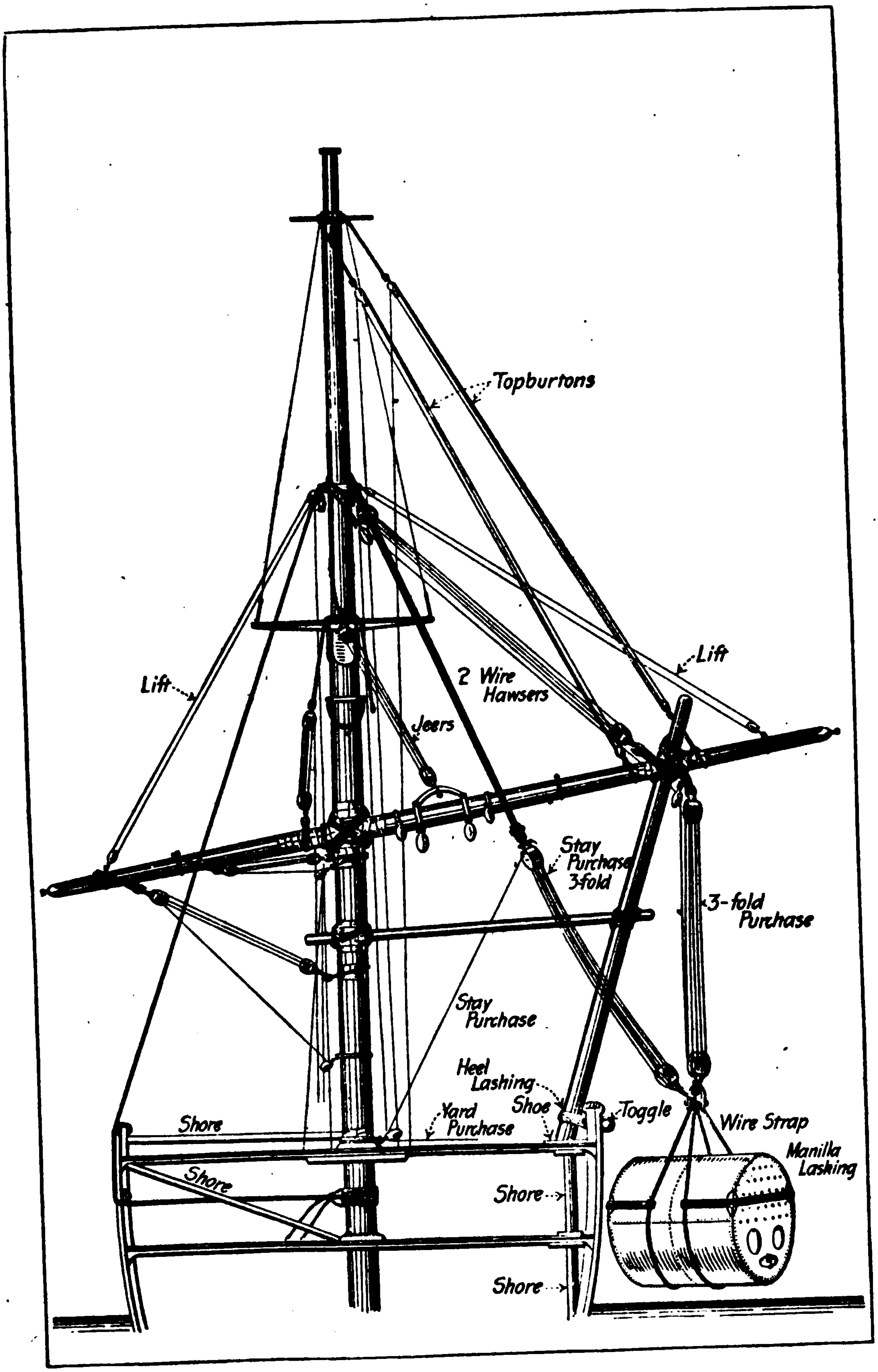
HANDLING WEIGHT BY A LOWER YARD.

tackle will usually give ample support for almost any weight that would be handled in this way; and if the lift is kept slack the yard may be braced with safety. If it is thought necessary to use two tackles, they may be hooked to the ends of a good strap rove through a thimble or a single block lashed to the yard. The "rendering" of this strap will keep the tackles taut alike as the yard is swung. In most cases the necessity for swinging the yard may be avoided by the use of a "stay-tackle" hooked at such point aloft and amidships that it will bring the weight in as the yard-tackle is eased away. If, in addition to the yard and stay, another tackle is used, hooking to a pendant from the fore topmast head (supposing that the main yard is in use), the weight may be landed at any point that is desired. It will be seen that the principle of the span is involved in this use of two purchases or pendants; and care should be taken not to let the angle between them become too great.

Wherever a yard is used as above described, the inward thrust along the yard must be considered. This is taken principally by the truss, but may be thrown upon the mast by hauling taut the opposite lift and using a "rolling tackle" from the quarter of the yard to a strap around the mast. If the weight to be handled is very great, the yard should be unkeyed from the truss, lowered as much as the conditions admit, and lashed to the mast. Plate 38 shows the manner of rigging the yard for an extreme case, where the weight to be handled is such as to call for every possible precaution. *Such an arrangement as this would not be practicable on a modern ship, but it is given here because of the fulness with which it illustrates the principles involved in handling weights.* Knowing the weight to be dealt with and the angles between the various spars and tackles used, we can calculate the strain upon any part of the system and the size of the rope required to meet it, by the rules of Chapters III and IV.

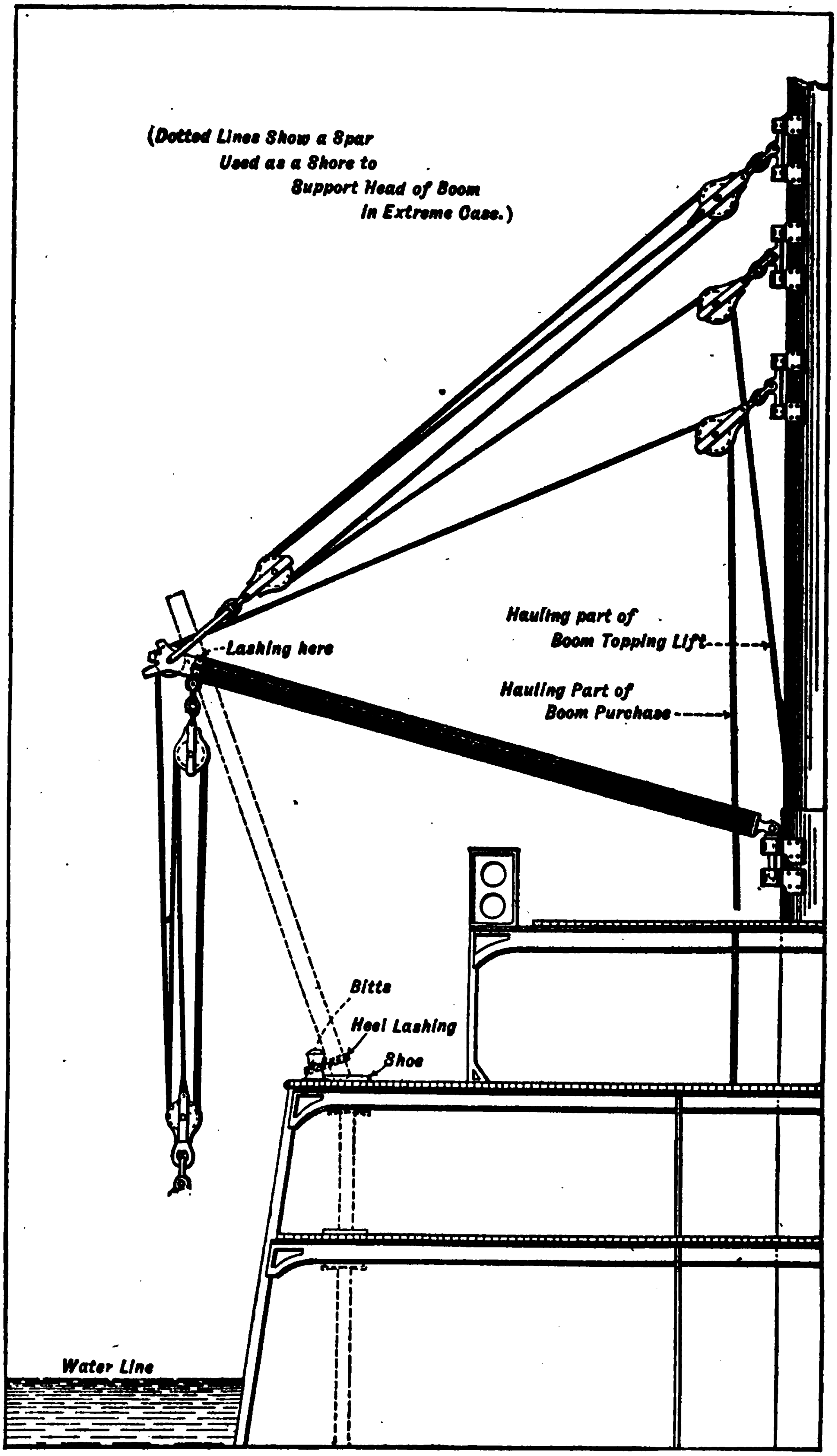
It is often convenient to use a span between two masts. This may, indeed, be the only way to plumb a hatch. In such a case the pendants must be secured as high as possible; since the smaller the angle between them, the less the tension to which they are subjected by a given weight. (See Chapter III.)

Modern ships as a rule have no yards which can be utilized for handling weights, but are fitted with booms swinging about



LOWER YARD RIGGED FOR HANDLING VERY HEAVY WEIGHT.

Plate No. 39.



BOOM FOR HEAVY WEIGHTS.

RIGGING A DERRICK FOR A HEAVY WEIGHT.

heavy pivot-bolts on the mast, and supported by topping-lifts and guys which admit of plumbing any point within a considerable range on deck and alongside. There is no difference in principle between such a boom and a yard rigged and used as has already been described, except that the yard has the characteristics of a long boom used nearly level. The cargo booms of merchant vessels and the boat-booms or cranes of men-of-war, are usually heavy enough for weights up to three or four tons, while the cranes of a battleship are designed to handle launches weighing six or seven tons. Plate **45.**

The range of power of such a boom may be considerably extended by the use of a spar as in Plate **39**, to take the direct downward thrust, the deck under the shoe of the spar being well shored up. This takes a large part of the tension from the topping-lift. It is well to block up under the pivot-bolt, or to unkey the boom and step the heel upon the deck. The boom itself may be strengthened by "fishing"; that is, by placing lighter spars along its length and lashing all securely together. If the boom is not conveniently situated for the work to be done, it may be transported to the point where it is needed and supported there by topping-lifts and guys, the heel being placed in a shoe and the deck below shored up as in all similar cases (Plate **40**).

If the boom is to be topped up or lowered with the weight hanging from it, the strength of the topping-lift must be calculated for the lowest position the boom will occupy, as this is the one in which the demand upon it will be a maximum. It must be remembered also that there will be a much greater tension on the fall of the topping lift than if the boom were fixed. This is due to the resistance of friction which must be added to the theoretical load as soon as the system is set in motion.

The anchor-davit may sometimes be utilized, assisted by a topping-lift from aloft if the foretopmast is so situated as to make this feasible.

Where the object to be handled is of such a nature as to admit of **parbuckling**, this is a simple and convenient method to use especially on a ship of low free-board (Plate **34**).

Where the ordinary resources of a ship are insufficient for the work in hand, a derrick or shears must be rigged, the materials being obtained where they can be found. Plate **41** shows the details of shears.

The heels of such derricks and shears are stepped in shoes,

which must be large enough to distribute the weight over a number of beams, and the decks below are well shored up. The shoes are lashed to prevent slipping, and in the case of shears are held from spreading by a thwartship tackle. The shear-head lashing is sometimes passed with figure-of-eight turns, but the method shown in Plate **41** is better. The lashing, being passed with the legs laid alongside each other, tautens as they are opened out. The shear-head is supported by topping-lifts and inclined as much as may be necessary. The more nearly upright the legs can be kept, the greater will be the proportion of the weight supported by the thrust of the spars and the smaller the demand upon the topping-lifts. The greater the distance from the heel of the derrick to the point where the guys set up, the less the strain upon the guys.

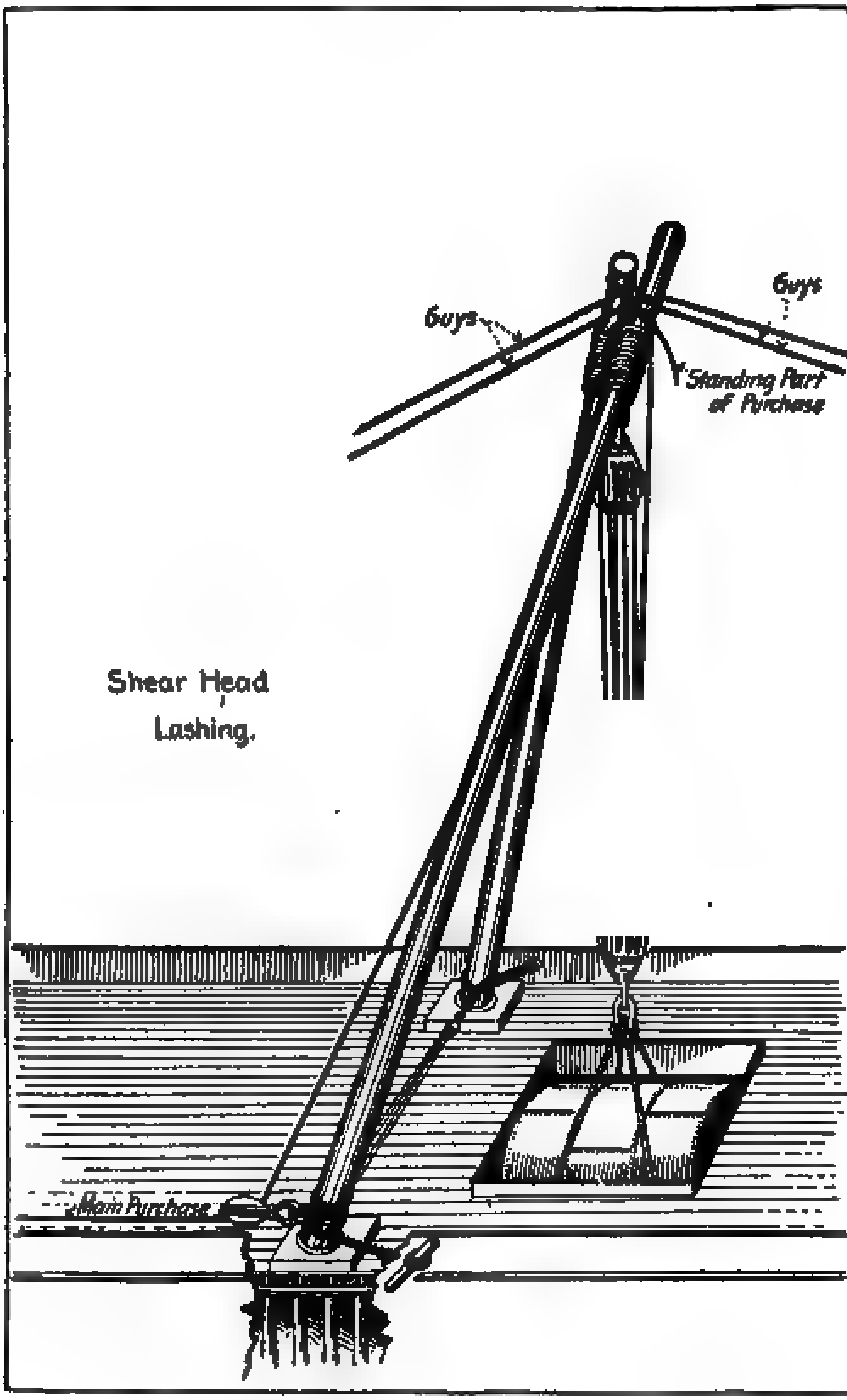
If the weight has first to be lifted from between-decks and afterward put over the side, it will usually be necessary to land it between the two operations. It is true that derricks (not shears) are constantly used to lift weights and swing them around, but these are derricks properly fitted and supported for it. With improvised arrangements and a heavy weight, it is wiser to land the weight and move the derrick or shears.

If it becomes necessary to rig the shears or derrick at a point where no mast is available for giving a lead to the topping-lift or guys, a mast may be improvised; the topping-lift being secured to this or led over it (through a good block) and set up as far from the mast as possible. Where the guys are to lead athwartships, an outrigger may be used on the off side of the ship, secured by a hawser dipping under the keel, and steadied by good lines forward and abaft.

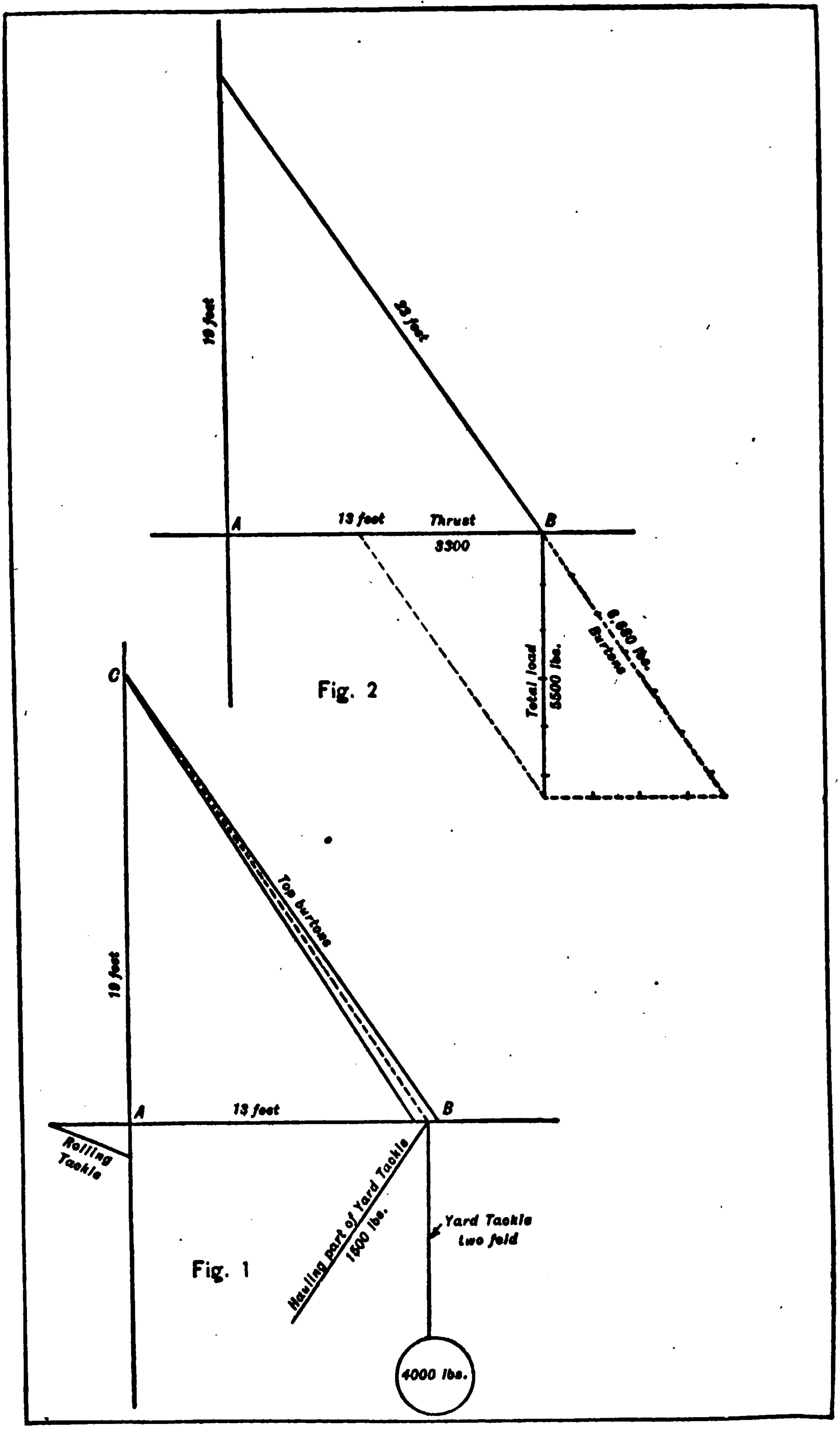
If not entirely sure that everything is going to hold, it is well to block up from deck to deck with heavy planks crossing the hatches under the object as it is hoisted from below, and following up as close to it as possible, so that it cannot drop more than a few inches if anything gives way. So in transporting it from the hatch to the rail it should be lifted only just high enough to clear the deck. If it must be raised for the purpose of clearing the rail, skids may be used from the hatch and the weight partly lifted and partly skidded across.

If the blocks and falls that must be used are not heavy enough for the work required, with the fall rove in the usual way, re-

Plate No. 41.



SHEARS FOR HANDLING A HEAVY WEIGHT.



HANDLING WEIGHTS BY A YARD.

sort may be had to the form of a tackle shown in Plate **33.** Here we have two tackles so far as power is concerned, but by making the fall continuous and using both ends of it for hauling, we distribute the friction more uniformly, since there is no "standing part." Another advantage is, that in cases where two distinct tackles are used there must be times when one will lag behind, leaving the weight entirely on the other. This cannot happen where the fall is continuous, as in Plate **33.** It is thus possible with blocks and falls of a given size, to handle a weight considerably heavier than would otherwise be safe.

All blocks should be thoroughly overhauled, and careful calculations made of the stresses to which all parts of the system are to be subjected. Shackles or lashings should be substituted for hooks whenever it can be done, and in other cases the hooks should be securely moused. Particular attention should be given to the running of winches to see that no surging is allowed in either hoisting or lowering. A heavy surge will nearly or quite double the strain.

Finally, in reeving the purchases, leading the falls, etc., attention should be given to the principles explained, and the rules laid down, in Chapters II and III.

Plates **31, 32** and **33** illustrate a variety of methods of slinging weights, hooking tackles, etc.

§ II. PRACTICAL EXAMPLES IN HANDLING WEIGHTS.

(See Rules of Chapters II and III.)

As the Rules above referred to are only approximations, it is unnecessary in applying them to work with mathematical exactness. In the solutions which follow, small fractions are neglected, but care is taken to keep, upon the whole, on the side of safety.

In many cases, a close estimate of the stresses can be made by the eye, without calculation, and it is well to accustom the eye to such estimates by an occasional test. Most of the calculations which are required can be made mentally, if the rules are well in mind. In important cases, however, it is worth while to make a careful sketch, to scale, and this will be found to involve very little trouble in comparison with the importance of the results depending upon it.

I.

A weight of 4000 lbs. is to be lifted by a yard, as in Plate 42, the yard-tackle to be a two-fold purchase, with the hauling-part leading from the upper block to the deck. Two top-burtons of 3-inch manila are available for supporting the yard. It is required to calculate the size of rope required for the yard-tackle, and to determine whether the top-burtons are heavy enough for the work.

(a) Total resistance of main purchase including friction $=$ $4000+\frac{5}{10}4000=6000$ lbs.

Maximum tension on fall $=\frac{6000}{4}=1500$ lbs. $=\frac{3}{4}$ ton (nearly).

Size of rope for $\frac{3}{4}$ ton $=\sqrt{15\times0.75}=3\frac{1}{2}$.

(b) The load on the yard is the actual dead weight, plus the tension on the hauling part.[1] $=4000+1500=5500$ lbs.

To find the tension on the lift, we construct the parallelogram of forces, as in the figure.

Tension of the topping-lift $=6660$ lbs.

Or we may note the length of the lift and of the mast (from A to C), and determine the tension by a proportion, thus:

Length of mast, $AC=19$.
Length of lift, $BC=23$.
Downward tension at $B=5500$ lbs.

$$\frac{\text{Tension on lift}}{5500}=\frac{23.}{19.}$$

Tension on lift $=6660$ lbs.

It should be possible to estimate this tension rather closely by the eye, without calculation, since it is easily seen that the lift is not far from $1\frac{1}{4}$ times as long as the mast.

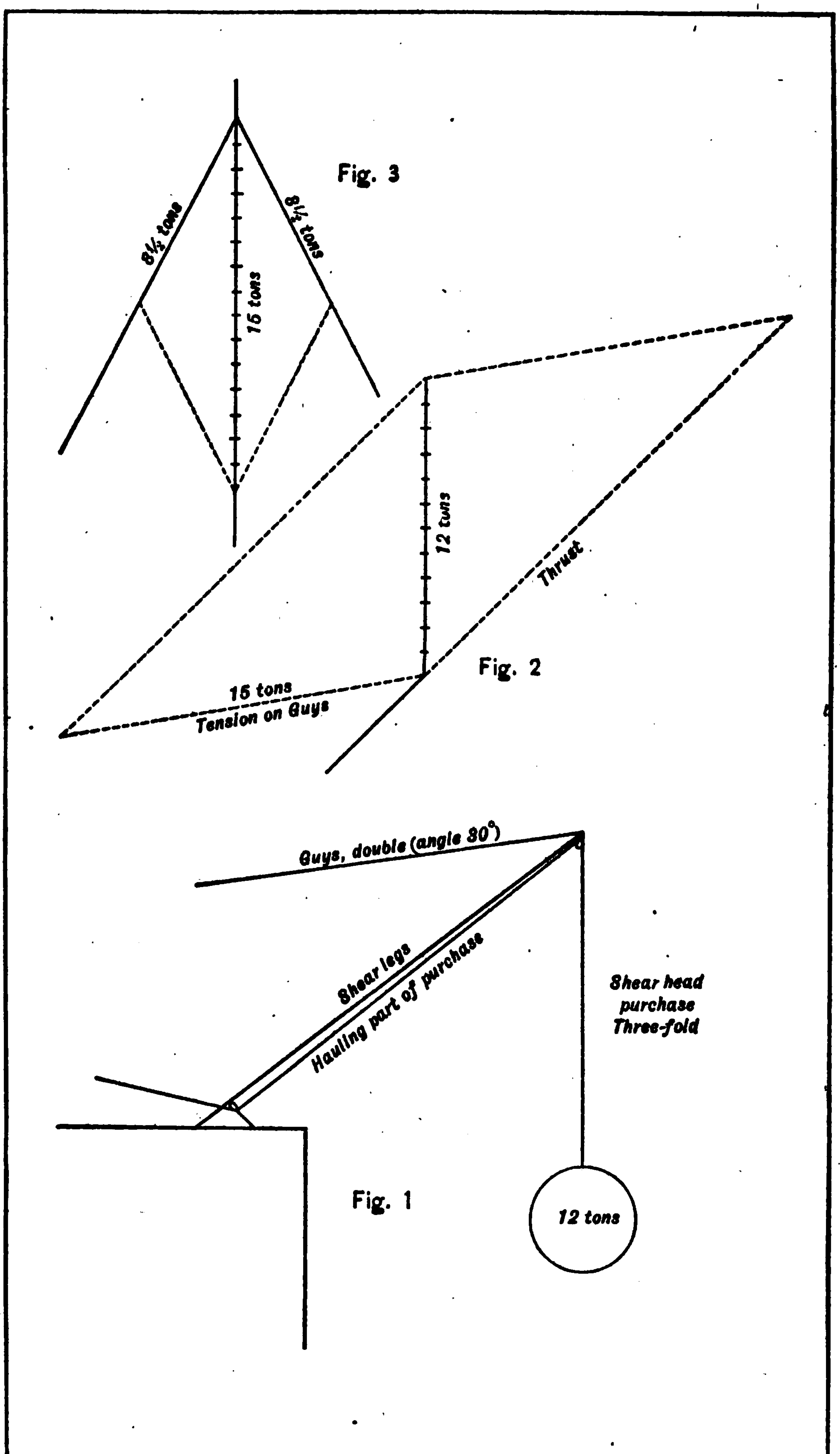
The tension will be divided between two top-burtons, each of which has three parts. As the yard is not to be moved, friction does not enter the problem. Each part will have to support one-sixth of the total tension, or, 1110 lbs. ($\frac{1}{2}$ ton).

To find the safe load for the rope of which the burtons are rove. Safe load for 3″ rope $=\frac{3\times3}{15}=\frac{6}{10}$ ton. (§IV, Chap. III.)

As this is more than the tension found above for each part, the burtons are heavy enough for the work.

[1] Strictly speaking, only the vertical component of the tension on the hauling part should be included here, but it is convenient and safe to count it as if the lead of the hauling part were vertical.

Plate No. 43.



HANDLING WEIGHTS BY SHEARS

(c) To determine the thrust on the yard.

Referring to the parallelogram of forces in Fig. 2, we have, Thrust = 3800 lbs.

Or we may calculate it by proportion, as follows:

$$\frac{\text{Thrust on yard}}{5500} = \frac{AB}{AC} = \frac{13}{19}$$
$$\text{Thrust} = 3800 \text{ (about).}$$

Here again it should be possible to make a close estimate by the eye, without calculation.

This thrust is supported by the truss, the lift, and the rolling tackle. By unkeying the truss and slacking the lift we may throw it entirely on the rolling tackle, which we will assume to be a two-fold purchase with the double block hooked to the yard. This gives 5 parts to divide the thrust.

Tension on each part = 760 lbs. = 0.33 ton.

Size of fall for this tension = $\sqrt{15 \times 0.33} = 2\frac{1}{4}$ inches (about).

NOTE.—This assumes that the rolling tackle is parallel with the yard. If the strap on the mast is below the yard, we find the tension on it by the parallelogram of forces.

2.

To lift 12 tons by sheers, as in Plate 43.

Sheer-head Purchase.—Three-fold, with the hauling part leading from the upper block, parallel to the sheer legs, and through a leader on deck. Two (single) guys are used, making an angle of 30° with each other.

Total resistance $= 12 + \frac{7}{10} 12 = 20.5$ tons.

Maximum tension on fall $= \frac{20.5}{6} = 3.5$ tons.

Size of fall required $= \sqrt{15 \times 3.5} = 7\frac{1}{4}$ inches (nearly).

To find the tension on the sheer-head, we neglect the tension on the hauling part of the sheer-head purchase, because this part leads parallel to the sheer-legs (where it adds to the thrust).

Load on the sheer-head = 12 tons.

By the parallelogram of forces we find,

Total tension on the guys = 15 tons. (Fig. 2.)

The tension on each guy = 8.5 tons. (Fig. 3.)

The size of rope to support this tension,

$= \sqrt{15 \times 8.5} = 11\frac{1}{4}$ inches for manila = 5 inches for wire.

12-inch hawsers are required for the guys by the above rules if

Plate No. 44.

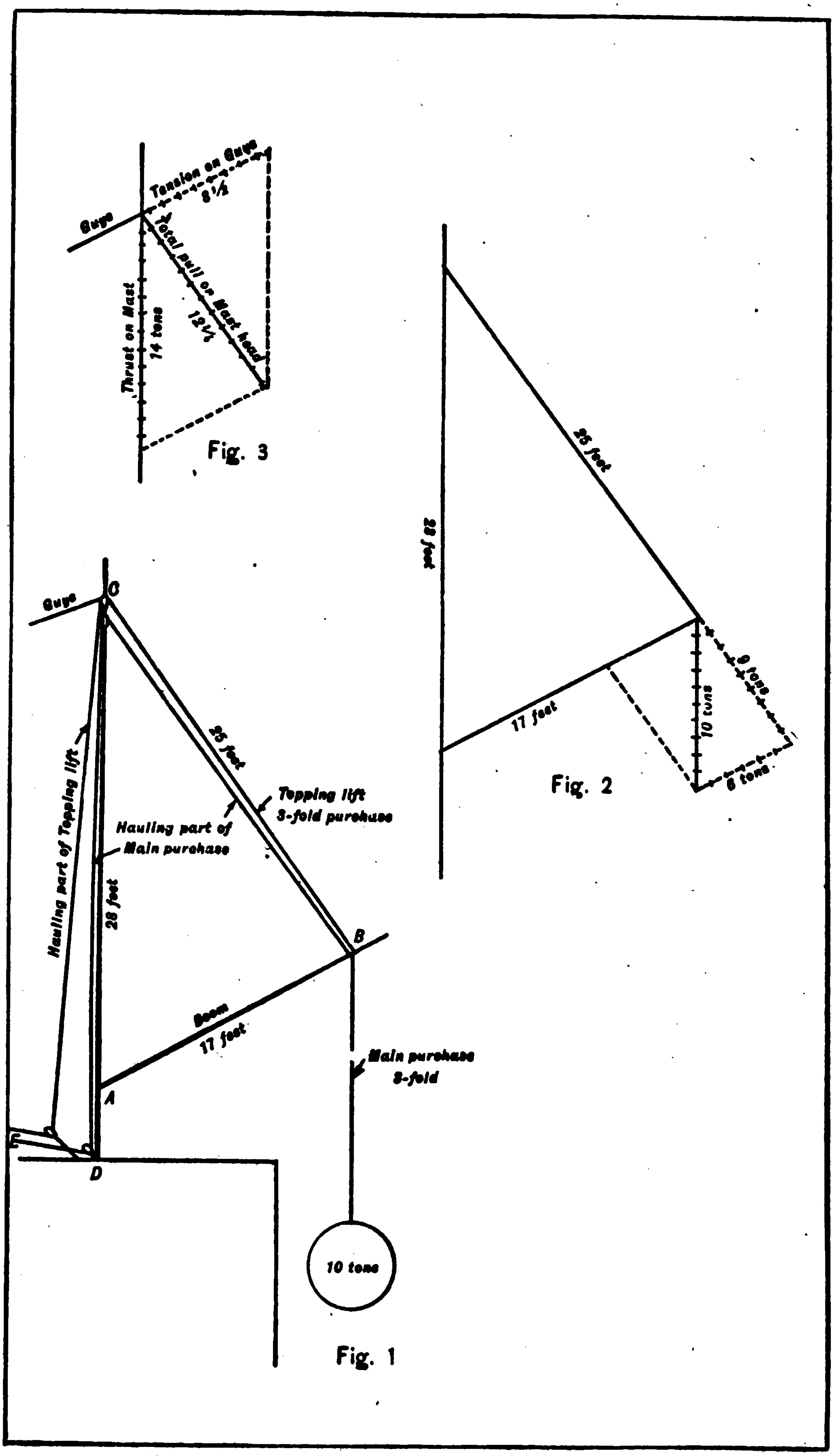


Fig. 3

Fig. 2

Fig. 1

HANDLING WEIGHTS BY A DERRICK.

of manila. It should be noted, however, that these rules are formulated for conditions very different from those of the present case and that they involve a factor of safety which is unnecessarily large for a standing rope to be used for a short time. For a case of this kind, we may safely reduce our multiplier to 8. Thus:

Size of rope $= \sqrt{8 \times 8.5} = 8$ inches (about), for manila $= 4$ inches for wire (approximately).

3.

It is required to lift a 10-ton boiler by a derrick as in Plate **44**, the boom to be topped up for landing the weight on deck.

Main purchase. Three-fold, the hauling part leading from the lower block, up through a leader at the boom end, then through a leader at the masthead, then through a leader on deck.

Total number of sheaves $= 9$.

Number of parts at the movable block $= 7$.

Topping-lift. Three-fold, the hauling part leading from the upper block, and through a leader at the foot of the mast.

Total number of sheaves $= 7$.

Number of parts at the movable block $= 6$.

(a) To find the size of fall for the main purchase.

Total resistance including friction $= 10 + \frac{9}{10}\,10 = 19$ tons.

Maximum tension on fall $= \frac{19}{7} = 2.75$ tons.

Size of fall required $= \sqrt{15 \times 2.75} = 6\frac{1}{2}$ inches (nearly).

(b) To find the size of fall for topping-lift.

The load on the boom is the dead weight of the boiler alone, diminished somewhat as a result of the fact that the standing part of the main purchase leads up to the masthead. It is safe and convenient, however, to consider the whole weight as hanging from the boom. In resolving this along the lines of the lift and the boom we take the boom at its lowest point, this being the point at which the load on the lift will be a maximum.

Resolving the forces (Fig. 2).

Load on topping-lift due to weight $= 9$ tons.

Or thus,

$$\frac{\text{Load on lift}}{\text{Weight}} = \frac{\text{Length of lift}}{\text{Length of mast}} = \frac{25}{28}$$

Load on lift $= 9$ tons.

This could be estimated closely by the eye.

Plate No. 45.

BATTLESHIP'S BOAT CRANE

Plate No. 46.

COALING BOOM.

As the boom is to be topped up, we must add the resistance due to friction, in calculating the strength of fall required.

Total resistance on topping-lift including friction,

$$=9+\frac{7}{10}9=16.3 \text{ tons (nearly).}$$

Maximum tension on fall of topping-lift $=\frac{16.3}{6}=2.75$ tons.

Size of fall required for topping-lift $=\sqrt{15\times2.75}=6\frac{1}{2}$ (nearly).

(c) *To find the tension on the guys.*

The pull on the masthead is the load on the topping-lift (9 tons) plus the tension on the part, BC, of the main purchase fall leading from the boom-end to the masthead.

We have found the tension on the hauling part DE, to be 2.75 tons. The tension on BC is considerably less than this, being reduced by the friction of two intervening sheaves; but for convenience we may neglect this difference, and take 2.75 tons for the tension on BC. This gives, for the pull to be resisted by the guys, $9+2.75=11.75$ tons. The tension on the guys is found from this as in other examples preceding.

Tension on guys $=8\frac{1}{2}$ tons.

(d) To find the thrust on the boom.

This is the resolved component along the line of the boom $=6$ tons.

(e) To determine what thrust the boom will safely stand. Diameter of spar 10 inches; length 17 feet.

By Rule 9, §IV, Chap. III.

$$T=\frac{4R^4}{L^2}=\frac{4\times5^4}{17^2}=8.6 \text{ tons.}$$

Hence the boom is strong enough to stand this thrust and also the increased thrust (about 20 per cent) which will result from topping up the boom to land the boiler on the deck.

CHAPTER VI.

THE COMPASS, LOG AND LEAD—SUBMARINE SIGNALS.

§ I. THE COMPASS.

The essential part of the compass is a magnetic needle which turns freely on a pivot, and which, if unaffected by local disturbing influences, would point due north and south (magnetic). The local influences which necessarily exist on ship-board and which on steel ships are very large, are more or less fully neutralized by the methods used to "compensate" the compass; and the needle does, in general, point approximately to the magnetic poles.

A recent experience in which a ship was stranded because a small piece of iron had been carelessly left near the compass suggests the necessity for a warning on this point. Iron or steel, even in masses as small as a pocketknife, if brought near the compass, may affect it. Helmsmen and quartermasters should understand this.

Stanchions, railings and other metal fittings near a compass should preferably be of bronze or other non-magnetic substance. If made of iron, they should never be absent, while the compass is in use, from the positions occupied when observations for deviation are made.

Attached to the needle and moving with it, is a circular card marked around its circumference with two graduations; one of points, half-points and quarter-points, the other of degrees. (Plate **47**.)

The card with the attached needle (or needles) is floated in a liquid composed of 45 per cent pure alcohol, and 55 per cent distilled water, within a chamber, where it is pivoted upon a jewelled bearing which keeps the card centered and supports a small fraction of its weight. On the inside rim of the card-chamber is a vertical mark known as the "**lubber's point,**" which, in installing the compass, is carefully adjusted in the fore-and-aft line of the ship with reference to the center of the card. In steering, this mark is held in coincidence with the point of the card indicating the course to be steered.

The graduation of the card in points and half-points runs as follows, beginning at North:

North.	**South.**
N. ½E.	S. ½W.
N. by E.	S. by W.
N. by E. ½E.	S. by W. ½W.
NNE.	SSW.
NNE. ½E.	SSW. ½W.
NE. by N.	SW. by S.
NE. ½N.	SW. ½S.
NE.	SW.
NE. ½E.	SW. ½W.
NE. by E.	SW. by W.
NE. by E. ½E.	SW. by W. ½W.
ENE.	WSW.
ENE. ½E.	WSW. ½W.
E. by N.	W. by S.
E. ½N.	W. ½S.
East.	**West.**
E. ½S.	W. ½N.
E. by S.	W. by N.
ESE. ½E.	WNW. ½W.
ESE.	WNW.
SE. by E. ½E.	NW. by W. ½W.
SE. by E.	NW. by W.
SE. ½E.	NW. ½W.
SE.	NW.
SE. ½S.	NW. ½N.
SE. by S.	NW. by N.
SSE. ½E.	NNW. ½W.
SSE.	NNW.
S. by E. ½E.	N. by W. ½W.
S. by E.	N. by W.
S. ½E.	N. ½W.
South.	**North.**

The enumeration of the points and fractional parts of points of the compass in regular sequence is called "**Boxing the Compass.**"

The delicacy with which steamers can be steered by means of the arrangements now employed for the purpose is leading to the disuse of points and quarter-points for compass work and the custom is becoming general of shaping courses and noting bearings, in degrees. The seemingly trifling error that may be

COMPASS CARDS.

Fig. 1.
Old Compass Card.

Fig. 2.
New Compass Card.

involved in attempting to steer by fractions of a point, while of little consequence to a slow vessel in a short run, may be vital to a steamer making four or five hundred miles a day.

As there are 32 points in the circle, each point evidently represents $11\frac{1}{4}°$ ($11° 15'$).

North, South, East and West are called "Cardinal Points"; **Northeast, Southeast, Southwest and Northwest,** "Intercardinal Points."

On the compass-card which has been in use until very recently, the graduation by *degrees* begins at North and at South and runs 90° to right and left toward East and West. Thus on this card we have, in the North-east quadrant, N. 1° E., N. 2° E., etc., up to N. 90° E.; and in the South-east quadrant, S. 1° E., S. 2° E., etc., up to S. 90° E. **East** may be regarded, therefore, as either N. 90° E., or S. 90° E.

Similarly we have in the North-west quadrant, N. 1° W., N. 2° W., etc., up to N. 90° W.; and in the South-west quadrant, S. 1° W.; S. 2° W., up to S. 90° W., so that **West** may be regarded as either N. 90° W. or S. 90° W.

Thus courses may be designated either in points or in degrees. NE. is N. 45° E.; ESE. is S. 67° 30 E.; SW. by S. is S. 33° 45′ W.; etc.

Compass Card U. S. Navy.

Plate **47** shows a new form of compass-card which has lately been adopted in the United States Navy. On this card the degrees run *in a continuous graduation* (to the right) completely around the circle from North to North again, through 360°. With this card, bearings and courses may be designated simply by the number of degrees from North. Thus North-east is "45°"; East is "90°"; South-west is "225°"; North-west is "315°"; etc.

For the present, the old points and quarter-points are retained on the card, but it is probable that they will ultimately be omitted.

The Gyroscopic Compass.[1]

This type of compass has been developed to a very high degree of accuracy and reliability during the last few years and is now extensively used on war vessels in the United States and in Europe. It is also in use on a few of the large Trans-Atlantic Liners. This compass is entirely independent of magnetism and is therefore not subject to the disturbing magnetic influences always

[1] By Lieut.-Commander Charles T. Owens, U. S. Navy.

found on board ship which often render the magnetic compass unreliable and for which careful compensation is required. It points to the true geographical pole instead of to the magnetic pole, thus eliminating the variation of the compass. As its directive force is very much stronger than that of the magnetic compass, errors due to lag and sluggishness of the compass are also eliminated.

A gyroscope, if so mounted as to have freedom of motion about three rectangular axes, will maintain its axis of rotation fixed in space, unless it is acted upon by some externally impressed angular force. Since it maintains its axis of rotation fixed in space, this axis will have an apparent motion relatively to the earth's surface, which is evidenced by its continually changing its inclination to the horizontal plane. To illustrate this, let it be supposed that the gyroscope is spinning with its axis pointing directly at a star in the horizon whose bearing is due East. It will soon be observed that the axis is following the star in its apparent diurnal movement. If in the Northern hemisphere it will gradually rise and turn toward the South, reaching its highest elevation in six hours when the star is on the meridian, and returning to the horizontal again in twelve hours when the star is bearing due West. That extremity of the axis pointing to the star will continue to follow the latter as it falls below the horizon, reaching its greatest depression in 18 hours and returning to the horizontal in 24 hours as the star again appears in the horizon. During this 24 hours the earth has completed one revolution on its axis while the star and the gyroscope have remained fixed in space. Had the axis of the gyroscope initially pointed to the celestial North pole (the North Star, approximately) its inclination to the horizontal would have remained unchanged throughout the 24 hours.

In the gyro-compass the spinning wheel or gyroscope is mounted in a casing on ball-bearings and is made to rotate at the highest practicable speed by an electrical alternating current induction motor. It is so suspended as to have freedom of motion about three rectangular axes, and would if not acted upon by any externally impressed angular force, have motion relatively to the earth's surface exactly as described above. By means of a weight applied to the casing carrying the gyroscope, however, gravity is made to impress an external angular force as soon as the axis of the gyroscope begins to tilt above the horizontal and the result is that the axis of the gyroscope is drawn toward the

meridian and is held pointing steadily to the North. This is in accordance with the following law discovered by Foucalt: "Any revolving mass such as a spinning wheel, tends to swing around so as to bring its axis of rotation parallel to the axis of any externally applied angular force and in such a relation that the direction of rotation is the same as the direction of the said applied or impressed force."

Combined with the gyroscope casing is a compass card graduated in a similar manner to the card of a magnetic compass, having its North-South line parallel to the axis of rotation of the gyroscope, and the entire structure is suspended from gimbal rings mounted in a binnacle or stand.

The mechanical devices employed to render the compass accurate and reliable not only on shore but on a moving ship where it is subject to the motions of rolling, pitching and yawing, are much too complicated to be described here. It may be stated, however, that the readings of the compass card must be corrected for certain errors due to the fact that on a moving ship the gyroscope is acted upon not by the simple Easterly motion of the earth alone but by the resultant of the earth's motion combined with the ship's and the axis will therefore be deflected from the true North by an amount depending upon the course and speed of the ship and the latitude. The correction may be made by mechanical correction devices attached to the compass which move the lubber's line by the proper amount to make the course as read off from the card, the true course, or it may be taken from tables or charts especially prepared for the purpose.

Electrically connected with the "master compass" above described are "repeaters" which may be located at various stations about the ship. These resemble in external appearance the ordinary magnetic compass and are so designed that they can be shipped in gimbal rings in place of peloruses for use in taking bearings, or rigidly mounted in front of the helmsman for steering purposes.

From the above description it will be seen that whenever the axis of rotation of the gyroscope in the gyro-compass is not pointing North and South, the rotation of the earth will cause an apparent tilting of the axis with relation to the horizontal plane, thus bringing gravity into play to swing the compass in to the meridian. In reality it is the horizontal plane of the earth which is constantly changing its inclination in space and it is this which

gives the compass its directive force. It follows therefore that at either of the earth's poles where the horizontal plane remains fixed in space the compass has no directive force and at the equator where the inclination of the horizontal plane is changing at the most rapid rate, the directive force is a maximum. This may be compared to the magnetic compass which has a maximum directive force at the magnetic equator and none at the magnetic poles. In this connection it is interesting to note that the directive force of the gyro-compass is not only many times greater than that of the magnetic compass at the equator but that on going into higher latitudes the directive force of the magnetic compass tends to decrease much more rapidly than that of the gyro-compass.

While the gyro-compass has practically replaced the magnetic compass wherever it is installed, it is considered necessary to retain the magnetic compass as a check on the gyro and for use in case of casualty to the latter. It is doubtful if the magnetic compass will ever be entirely dispensed with on any ship.

The Pelorus or Dumb Compass is a circle marked with the graduation of a compass-card, but without a needle, which may be mounted at any part of the ship for use in taking bearings. A zero-line on this instrument is permanently fixed parallel to the fore-and-aft line of the ship, and a movable sighting bar admits of measuring at any instant the angle between the heading of the ship and an object sighted upon. This instrument may therefore be used for determining the compass-bearing of any object, the ship's-head by compass and the bearing of the object by the pelorus being noted simultaneously. Bearings may thus be taken of objects which cannot be seen from the compass. A convenient form of the pelorus is one in which the graduated circle can be turned inside of the fixed rim which carries the zero-mark, while the sighting-bar turns independently of both. In this form of the instrument, the point of the movable circle corresponding with the compass course of the ship is made to coincide with the zero-mark, so that the compass bearings of objects sighted upon are read off directly, *provided that the ship is exactly on her course at the instant of making the observation.* If it is necessary to make the observation while she is not on the course for which the pelorus is set, the difference must be noted and applied to the bearing observed.

Suppose the pelorus is set for a course *West*, and an observation taken when the ship is actually heading to the *left* of this course:—say W½S.

The bearing given by the pelorus must be corrected by ½ point applied to the left (like westerly deviation). If, the pelorus being set as before for West, the ship actually heads to the *right* of this course—say W½N—the correction must be applied to the right, like easterly deviation.

The accuracy of the adjustment of the zero-line in the keel-line of the ship may be determined by setting the circle to the compass course and taking simultaneous bearings with the compass and pelorus of a distant object. If an error is found to exist, it may be noted and applied as a permanent correction to all observations taken with the instrument; or the adjustment may be corrected.

Evidently, if the pelorus is set for the *magnetic* instead of the compass course, the bearings observed with it will be *magnetic.*

The latest type of Pelorus in the United States Navy carries a small range finder which admits of determining the bearing and distance of an object simultaneously. Attached to it also is a Gyro Compass.

COMPASSES SUPPLIED TO SHIPS OF THE UNITED STATES NAVY

The following are usually installed in capital ships:

Magnetic.

1 On Bridge, amidships. Steering.
1 Inside Cage Mast. Standard.
1 In Steering Engine Room.

Gyroscopic.

1 On Bridge, off center line, near Steering Compass.
1 In Conning Tower.
1 In Steering-Engine Room.
1 On Bridge, connected with Pelorus.
1 In Central Station.
Repeaters in various parts of the ship.

§ II. THE LOG.

The old-fashioned **chip-log** is still found on most ships, although very rarely used. The chip or " ship " is a flat piece of wood, in shape a sector of a circle, weighted with lead along its rounded edge. Three lines, forming a triple span, are led from its corners to a toggle and socket of wood on the log-line. By jamming the toggle into the socket, the span is completed; and if the chip is thrown overboard it will stand vertically in the water, opposing the resistance of its surface to motion through the water, and so long as no considerable pull is put upon the line, may be regarded as affording a fixed point from which to

measure the distance run by the ship in a given interval of time. The line is coiled on a reel which turns freely and the line is paid out fast enough to avoid danger of dragging the chip, a certain length of stray line being paid out to get the chip clear of the wake, before the measurement begins. The line is marked and the time noted as described below; and "**heaving the log,**" if carefully done, gives a close approximation to the *momentary* speed of the ship. If the speed varies, repeated observations will give a fair idea of the average speed for an hour or a day.

The interval of time is usually noted by a sand-glass marking either 14 or 28 seconds, but a watch may of course be used. The line is marked in "knots" and tenths, a knot as here used being the same part of a nautical mile that 28 seconds is of an hour. If the short glass is used (14 seconds), the speed indicated must be doubled.

To calculate the length of a knot on the log-line, 3600 secs.: 28 secs. :: 6080 feet: 47 feet 3 inches. The marking of the line should be frequently verified, the line being always wet when measured.

For heaving the log, three men are needed; one for the reel, one for the glass, and one, usually an officer or a quartermaster, to attend the line. The reel is held clear of everything and at right angles to the line as the latter runs out. The glass is held ready for turning sharply, care being taken that all the sand is in the lower bulb. The man who is to actually heave the log stands at the taffrail and taking the line in his hand just above the toggle hauls three or four fathoms of slack line from the reel and gathers it in a coil in his hand. When ready, he calls out "*Clear glass?*" and upon receiving the answer "*Clear glass!*" throws the chip and the slack line clear of the dead water under the stern. As the line straightens out, he hauls off more line from the reel with one hand and lets it slip through the other.

As the mark indicating the limit of the "stray" line comes off the reel, he calls out "*Stand by*" and as it leaves his hand, "*Turn!*". He continues to pay out the line, taking care not to leave it too slack, nor yet to drag the chip. The man holding the glass turns it promptly at the order, and watches as the sand runs through. As it approaches the end, he calls "*Look out!*" and as the last of it runs through, "*Up!*". At this the line is stopped and the knots and fraction of a knot that have run out give the speed if the 28-second glass is used, or half the speed with the 14-second glass. A smart jerk of the line pulls out the

toggle, allowing the chip to float freely, and the line is hauled in.

The chip-log may be conveniently used by a ship at anchor, for measuring the velocity of the current. It must be remembered, however, that if the chip floats at or just below the surface, it shows only the surface current. A pole with a weight at the bottom may be used instead of the chip to indicate current actually acting upon the ship.

PATENT LOGS.

The speed of modern steamers is measured by patent (mechanical) logs of which there are many types in the market. With a few exceptions, these consist of a "rotator," in principle like the propeller of a ship, which is towed through the water and thus made to rotate with a velocity varying directly with the speed, and a series of gears and dials to which the motion of the rotator is transmitted by a cord, the dials registering the distance corresponding to the revolutions of the rotator. In a "taffrail" log, the registering mechanism is on the taffrail and a long line is used between it and the rotator; in a "harpoon" log, the registering mechanism is towed astern with the rotator and must be hauled in for reading. As the record of a patent log is one of distance and not of speed, we must, to find the speed, note the run for a given length of time.

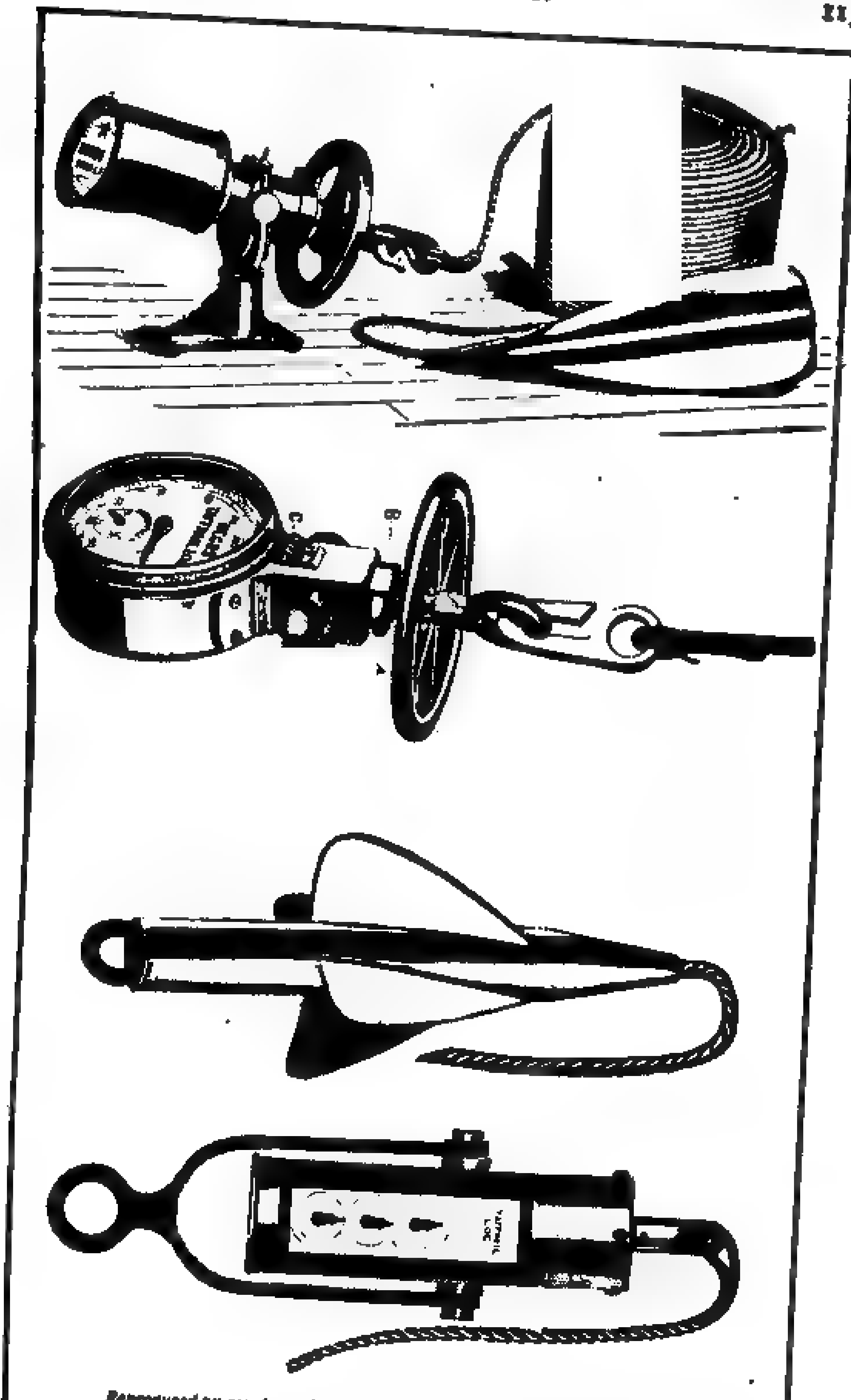
Plate 48 shows several types of patent logs in common use. By a simple "make-and-break" attachment, the record of the rotator can be transmitted electrically to a dial in the chart-house or elsewhere.

A patent log should be given the same care that is accorded to other mechanical devices from which accurate working is expected. It should be oiled daily when in use and kept in a dry place at other times. Logs of the harpoon type should be washed in fresh water before being stowed away.

When a log is first put in service, care should be taken to determine accurately its percentage of error. This will be found to vary considerably with the speed, a log which runs correctly at ten knots, being, perhaps, materially in error at fifteen.

The only way to determine the error satisfactorily is by runs of some length between known points where the effects of wind and tide are small. As some effect must always be expected from such causes, a number of runs will be needed to get a reliable error; and for every run that is made, a record should

Plate No. 48.



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PATENT LOGS.

be kept of the comparison between the distance made good by chart and that recorded by the log, a distinguishing number or letter being assigned to each rotator and each register so that their identity may be preserved throughout the record.

If the record shows also the draft of the ship, the revolutions of the engines and the details of wind and sea, it may be of great value.[1]

The length of log-line used has much to do with the working of the log. The proper length to use under ordinary circumstances is that issued with the log by its makers; but it is found that a greater length is needed for a high than for a low speed.

Logs are commonly accompanied by instruments for changing the pitch of the rotator-blades to correct an error in running, but unless the error is very great it is better to leave it and apply the correction found from observation.

The revolutions of the screw of the ship afford a valuable check upon the log and a means of replacing it if necessary, provided the record of revolution has been kept in connection with the record of the log, and provided also that this same record gives the draft of the ship and the condition of the bottom. Vessels like the trans-Atlantic liners, which make long trips at high speed, sometimes use their patent logs only when nearing land, as it is found that the wear on the bearings of a log at such speeds is very destructive. The fact that these vessels make trip after trip at almost unvarying speed enables them to run with great accuracy by revolutions alone. So, too, boats like the Sound and River steamers of the United States, when running in a fog, depend very largely upon the revolutions and rarely come to grief.

It must be remembered that all the methods which have been described above give the speed through the water, not over the ground. To get the speed over the ground, use is sometimes made of a "ground-log" consisting of a moderately heavy lead on the end of a log-line. The lead is thrown over and allowed to sink to the bottom, after which the line is paid out and the time noted exactly as in the case of the chip-log, care being taken not to drag the lead. This method not only gives the speed over the bottom, but shows the direction of the set.

Its availability is confined to rather shallow water and to moderate speeds.

[1] The draft of the ship has to do with the revolutions of the screw in relation to speed; not with the performance of the log.

THE NICHOLSON LOG.

The records given by the logs which have been described above are records of distance and not of speed. From the distance recorded in any given interval of time we can find the average speed during that interval, but not the actual speed at any instant.

The Nicholson Log, on the other hand, aims to give both the distance run and the instantaneous speed, together with a continuous graphical record of speed.

In principle, this log consists of a vertical tube passing through the bottom of the ship and projecting several inches below. The lower end of the tube is closed, but an opening in the *forward* side gives free entrance to the water, which accordingly rises, when the ship is at rest, to a level corresponding with the height of the water outside; that is to say, with the momentary waterline of the ship. As the ship moves ahead, the pressure due to her speed is communicated to the column of water in the pipe where it is added to the pressure due to the "head" of water outside, with the result that the column rises in the tube to a height which depends upon the speed and which may thus be made a measure of the speed. Inside the tube is a float attached to a chain which passes over a sprocket-wheel connected through suitable gearing with a pointer which indicates the speed, as the float rises and falls with the water in the tube. A counter-weight at the other end of the chain balances the float.

It is evident that the adjustment of the instrument will vary with the draft of the ship and that some compensating mechanism is needed to meet these variations. For this purpose a second pipe is fitted which opens through the bottom of the ship but does not extend below it. In this "equalizer pipe," as it is called, the height of the water is unaffected by the speed and the column stands always level with the water outside. In this tube is a float, which remains always at the same point as long as the draft is constant, but rises or falls as the draft changes. This float, like that in the speed-pipe, is connected through a chain and sprocket-wheel with the recording mechanism, to which it is geared in such a way as to compensate automatically for changes in draft.

The speed of the ship is indicated continuously on the speed dial; and the distance run is added up by a counter, so that a glance at the indicator shows at once both the instantaneous

speed and the distance made good, *through the water*. Moreover, the speed is recorded graphically on a record-sheet which is carried on a drum revolving by clockwork.

This instrument was at one time very generally used in ships of the United States Navy but it has not proved satisfactory in practice and has been removed from most of the ships.

§ III. THE LEAD.

The ordinary method of getting the depth of water is by means of a "lead" and line. A hand-lead, used for moderate depths, may weigh anywhere from 7 to 14 lbs. and a good leadsman will get soundings in depths up to 5 fathoms with the ship going 8 knots. If reliable soundings are wanted in depths greater than this, the speed must be reduced or the sounding-machine used.

The old style of marking the lead-line was as follows:

At	2	fathoms,	with 2 strips of leather.
"	3	"	" 3 " " "
"	5	"	" a white rag.
"	7	"	" a red rag.
"	10	"	" a piece of leather with a hole in it.
"	13	"	the same as at 3 fathoms.
"	15	"	" " 5 "
"	17	"	" " 7 "
"	20	"	with 2 knots.
"	25	"	" 1 knot.

The above are called the "marks." The intervening depths are "deeps."

The old style of reporting the soundings was:

"By the mark, three!"

"By the deep, four!"

"A quarter less, three!"

"And a quarter, four!"

etc., etc.

This method of marking the lead-line and of reporting soundings is antiquated and should be obsolete. A lead-line should have a mark for every fathom and half-fathom up to 10 fathoms; and for a considerable range—covering the depths that are critical for the ship using it—it should be marked in feet. Thus, if a ship draws 20 feet of water, there should be a mark

at every foot between 20 and 30. The soundings should be reported by the leadsman, sharply and clearly, in fathoms and fractions for depths exceeding, say 6 fathoms, and in feet for depths below this.

The lead-line should be of some material that will neither stretch nor shrink excessively as it is alternately wet and dried. An ideal material for this purpose has yet to be proposed. It may be that wire-rope of sufficient flexibility will some time be put on the market.

The lead-lines (wet) should be carefully measured and re-marked, each time they are to be used.

As the mark at the water's edge cannot be seen at night, some navigators like to mark their lines in such a way that the depth is indicated by the mark *in the leadsman's hand* when the line is up and down. This calls for a length of stray line equal to the drift from the water's edge to the leadsman's waist; this distance being laid off on the line before beginning to measure for the marks.

SOUNDING MACHINES.

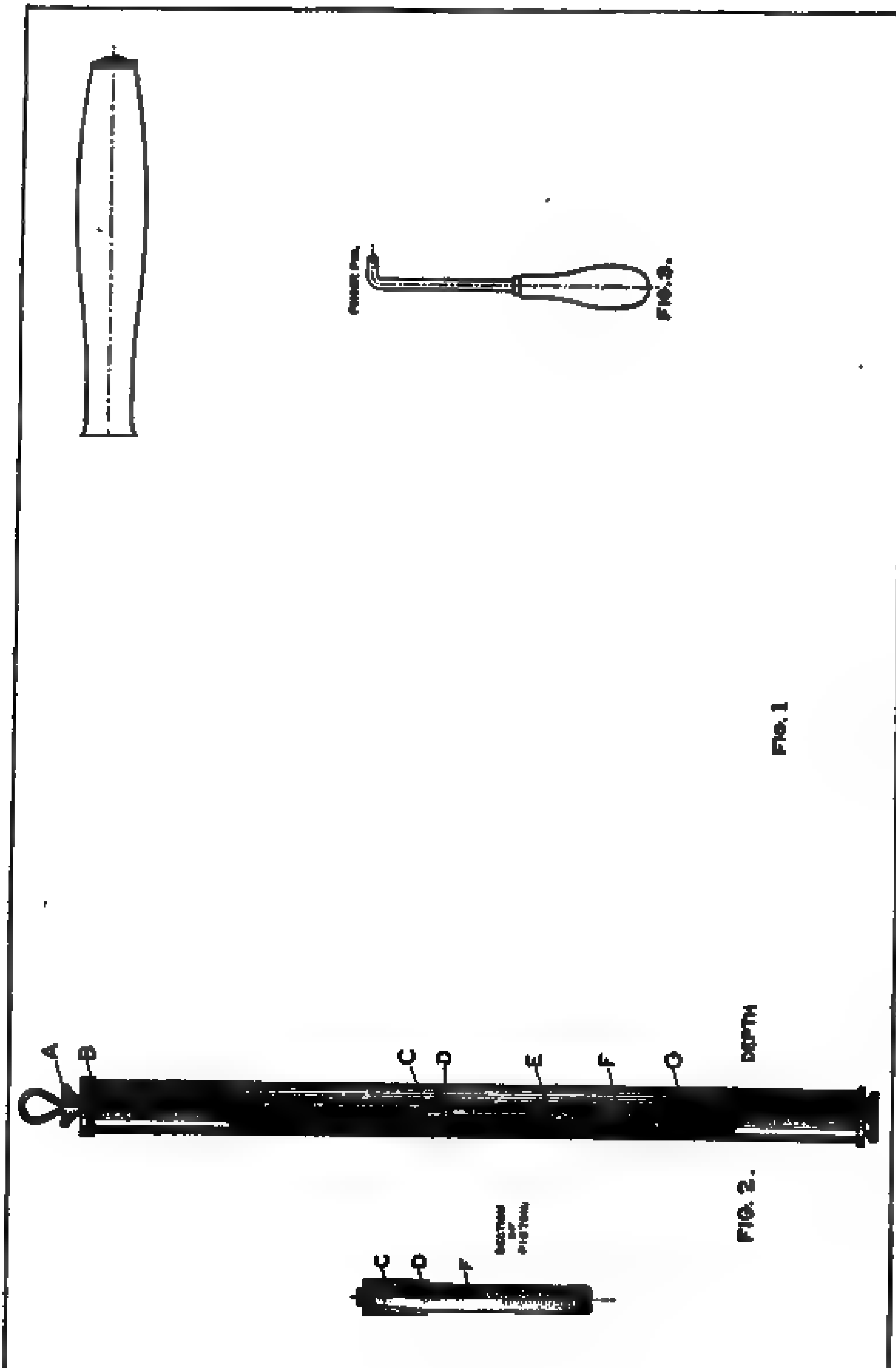
There are several types of sounding machines, all of which are greatly superior to the clumsy and antiquated deep-sea lead. Of these the best known and most generally used is that of Lord Kelvin, formerly Sir Wm. Thomson.

THE KELVIN SOUNDING MACHINE (Plate 49).

This consists of a wooden frame bolted to the deck and carrying a drum upon which are wound several hundred fathoms of galvanized piano wire. The drum is controlled by a brake, the operation of which is explained below. Attached to the end of the wire is a metal cylinder; and beyond that and connected with it by a short length of *plaited* rope is a heavy sinker. This rope, carrying the sinker, etc., is connected to a *link* which is permanently attached to the end of the wire.

The metal cylinder carries a slender tube of glass, closed at one end and coated on the inside with chloride of silver, which changes color upon actual contact with sea-water. This tube is placed in the metal cylinder with its open end down. As it sinks, the water rises in the tube, the air with which the tube was originally filled being compressed with a force which depends upon the "head" of water acting upon it. As this "head" depends upon the depth, it follows that the compression of the air and

Plate No. 49.



KELVIN SOUNDING MACHINE.

hence the height to which the water rises in the tube, becomes a measure of the depth.

With properly coated tubes, carefully used the limit of discoloration is marked by a sharply defined line, and the depth corresponding to this line is read off by a scale marked in fathoms.

To do away with the inconvenience and expense connected with the use of tubes, Sir William Thomson has invented a "depth-recorder" in which the water-pressure acts upon a piston against the tension of a spring. The spring and piston are enclosed in a composition cylinder, and the distance by which the spring is compressed is recorded by a marker on the piston stem. This device is convenient and generally accurate, but has not the reliability of the tubes.

The Depth-Recorder is shown in Fig. 2, Plate 49. As the sinker descends, the increasing pressure forces the piston D up into the tube, while the spiral spring pulls the piston back. The amount that the piston is forced up against the action of the spiral spring depends on the depth. To record the depth, the marker E is used. As the Recorder goes down, the marker is pushed along the piston. When the Recorder is brought up to the surface of the water, the piston comes back to its original position, but the marker remains (by friction) at the place on the scale to which it was pushed, and shows the depth to which the Recorder has sunk. The depth is indicated by the cross wire of the marker.

After each cast the nut A should be unscrewed to slacken the valve B, and the Recorder should be turned upside down to empty out any water which may have leaked in. A little water in the upper bottle will not interfere with the accuracy of the indications of the Recorder. It may not be found necessary to empty the bottle every time. Make sure before each cast that the screw A is firmly screwed up and the marker set to zero.

Occasionally a little grease should be pushed up the piston into the tube to keep the leather packing of the piston in good order.

The packing should always be examined before using, if the Recorder has not been used for some time.

Fig. 1, Plate 49, shows the mechanical details of the Kelvin machine.

A is the drum carrying the wire and turning freely on the shaft, S. B, B′ are two circular plates carrying bevel-shaped blocks of wood which, when the plates B B′ are drawn together, bind upon the beveled surfaces of the drum and form a friction-brake. B is keyed rigidly to S, but B′ is free. Upon the shaft outside B is a nut C, engaging a thread on the shaft. C has an arm D, which projects upward to a clamp, E, attached to the

frame of the machine and therefore fixed. Thus so long as D is engaged in E, the nut C cannot turn, and if the handle, H, is turned, the shaft will work through the nut, drawing the friction plates together and binding them upon the drum, or working them apart and allowing the drum to turn freely.

A small cogged-wheel, turning with the reel, engages a set of gear wheels by which the length of line that is out is registered upon a dial on the side of the machine.

In another (later) form of the machine, the nut and arm, C and D, are in one with the plate B′. In other words, the arm D is rigidly attached to B′, the nut C is omitted, and B′ has a screw thread which engages the shaft. It is as if the nut and arm in the type of Plate **49** were bolted to B′. This in no way changes the working of the machine.

The brake being on, the sinker, tube, etc., are lowered over the stern and when all is ready the brake is released by a partial turn of the handle. The wire runs out freely until the sinker touches bottom, when the line slacks suddenly. This is a critical instant, as the slacking of the line introduces danger of *kinking*. The brake is instantly thrown on by turning the handle back, and the wire tautens again at once. It is clear that the wire cannot be reeled in unless the nut and arm (C and D) are allowed to turn; for so long as they are held, the shaft in turning will be merely screwing the friction plates (B B′) more tightly upon the drum. To reel in, therefore, we release D by throwing up the hinged clamp E, which allows the reel, friction-plates, and nut, to turn together, reeling in the wire.

In handling the apparatus after a cast, care should be taken to keep the glass tube upright. If it is capsized, a little water may run into the upper part of the tube and spoil the record.

As the wire runs out, a little downward pressure is kept upon it with the brass "finger-pin" shown in Fig. 3. This is held by the man at the brake, who "feels" the wire with it, just clear of the reel. As the wire slacks, he bears the bight downward at the same time that he throws on the brake. This helps to prevent kinking on the reel.

In the latest machines, the simple piano wire is replaced by a seven-stranded, flexible, galvanized steel wire-rope of about the same diameter as the old style wire ($\frac{7}{100}$ inch diameter). This is much less likely to kink.

The following directions for using the machine are from a

pamphlet issued by Messrs. John Bliss & Co., of New York, the American agents of the makers.

1. The work of taking a cast is to be done by two men, under the superintendence of an officer. For brevity, the men will be referred to as brakesman and leadsman. The regular post of the brakesman is at the starboard side of the sounding machine. The regular post of the leadsman is beside the taffrail fair-lead.

2. The men go to their posts, and without further orders the brakesman puts on the two handles and fixes them securely by means of the screws. At the same time the leadsman sees that the lead is properly armed, and takes it along to the fair-lead. The officer examines the tube and places it in the guard-cylinder.

3. The brakesman standing on the starboard side of the machine sees that the arm D is prevented from turning by means of the catch. He then takes hold of the handle and puts the brake on by turning the handle in the direction for winding in the wire. When the brake is sufficiently tightened, the brakesman calls out "brake on." The leadsman then lets down the sinker without a jerk till it hangs upon the rope. The brakesman then, holding the handle in one hand, releases the arm D and pays out by turning the handle until the link (connecting the plaited rope to the wire) has passed over the fair-lead. The leadsman then calls out "on brake"; at which order, the brakesman engages the arm D in the catch E. The brakesman then reports "brake on," and the leadsman allows the sinker to hang free.

4. The brakesman now, having seen that the index of the counter is at zero, takes the brass finger-pin,[1] and holding it lightly by its handle, presses it against the wire and waits for the officer to give the order "let go."

5. The brakesman instantly turns his handle in the direction for paying out until the drum with wire rotates freely. While the wire is running out he holds the handle in one hand and the finger-pin pressing against the wire in the other hand. The brakesman watches the counter, and if the bottom has not been reached before coming to 250, *he commences to apply the brake as soon as he sees the index of the counter at 250, so as to stop before 300 is reached* As soon as the brakesman feels the wire slacken, he at once begins turning the handle in the direction for hauling in, until the brake is tightened up and the egress of the wire stopped. He then releases the arm D and commences to wind in.

6. The leadsman winds with his left hand and guides the wire to the drum with a piece of waste canvas in his right hand. The brakesman, winding with both hands, watches the counter from time to time during the winding in, and when the link is 5 fathoms from the fair-lead, he calls out "hand the lead."

NOTE.—When the speed exceeds ten knots it is desirable to have another man to help in the winding. He is to stand looking aft, and to work with

[1] The brass finger-pin is supplied with the machine, but if it should be missing or lost a piece of hard wood will do to press on the wire while the sinker is going to the bottom.

both his hands on the port handle, the leadsman working on the same handle with his left hand.

7. The leadsman instantly leaves the machine, goes to the taffraii, and steadies the link and cord by his hand as they come up, and guides the link over the fair-lead; while the brakesman continues slowly winding in until the link reaches the wire drum; and placing it properly on the wire drum he winds in one turn more; then, taking care that the link is a little above the middle of the after side of the drum, so that its weight may help to keep the wire stretched, he puts on the brake. Meantime the leadsman hauls by hand on the sinker. The leadsman then takes the lead on board, shows the tube to the officer, examines the arming for specimen of bottom, shows it to the officer, and prepares the arming for a fresh cast, and then goes forward to the machine and stands by for another sounding.

8. The reading on the counter shows approximately the number of fathoms of wire run out. This may be something more than twice the depth for speeds under 11 knots; or it may be almost as much as three and a half times the depth if the speed be 15 or 16 knots. The proportion of wire to depth differs not only with the speed of the ship, but also with the depth, and with the tension on the wire caused by the friction of the bearings and the handling of the brake. (See description of Kelvin Mark IV machine.)

Cautions and Explanations.

9. The wire will break *at a kink* under a very moderate pull or a very slight jerk. Without a kink, and with proper care, the wire can scarcely be broken in practice with the machine. No wire should ever be lost in service, unless by some extremely rare accident, not foreseen, and therefore not provided against.

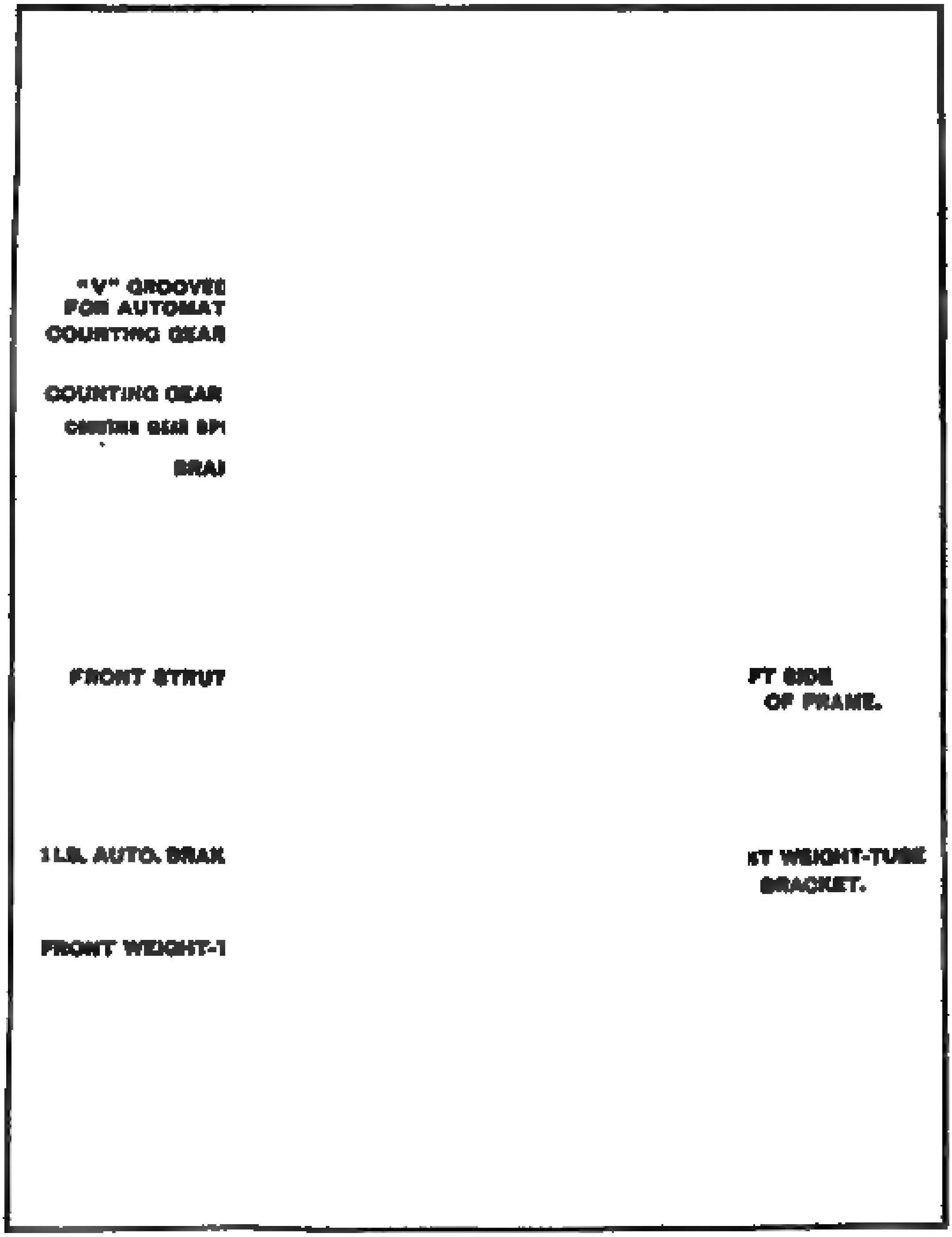
10. Absolute security against kinks would be had if the wire could be prevented from ever slacking. It does slacken somewhat the moment the lead touches the bottom, but not to a dangerous degree if the ship is going at anything more than 5 knots, and if the brake is instantly applied, when, by the wire's yielding to the brass pin, the commencement of slacking is shown. The brake should be instantly applied, so as to slow the motion of the wheel, but not with force enough to stop the wheel suddenly. There is much more danger of losing the wire through a kink in taking an up-and-down cast than in a flying cast with the ship running at 12 or 14 knots. *Whenever a cast is taken at any speed less than 5 knots, it is advisable to manage the brake so as to moderate the speed of egress according to judgment, letting the wheel run round at something like three turns per second.* If the ship's speed is more than 5 knots, observe all the rules laid down in the instruction preceding.

KELVIN SOUNDING MACHINE (Mark IV, Plates 50 and 51).

This is a late type of the Kelvin (Thomson) machine embodying the following very important improvements:

1st. The length of wire which runs out, as indicated by

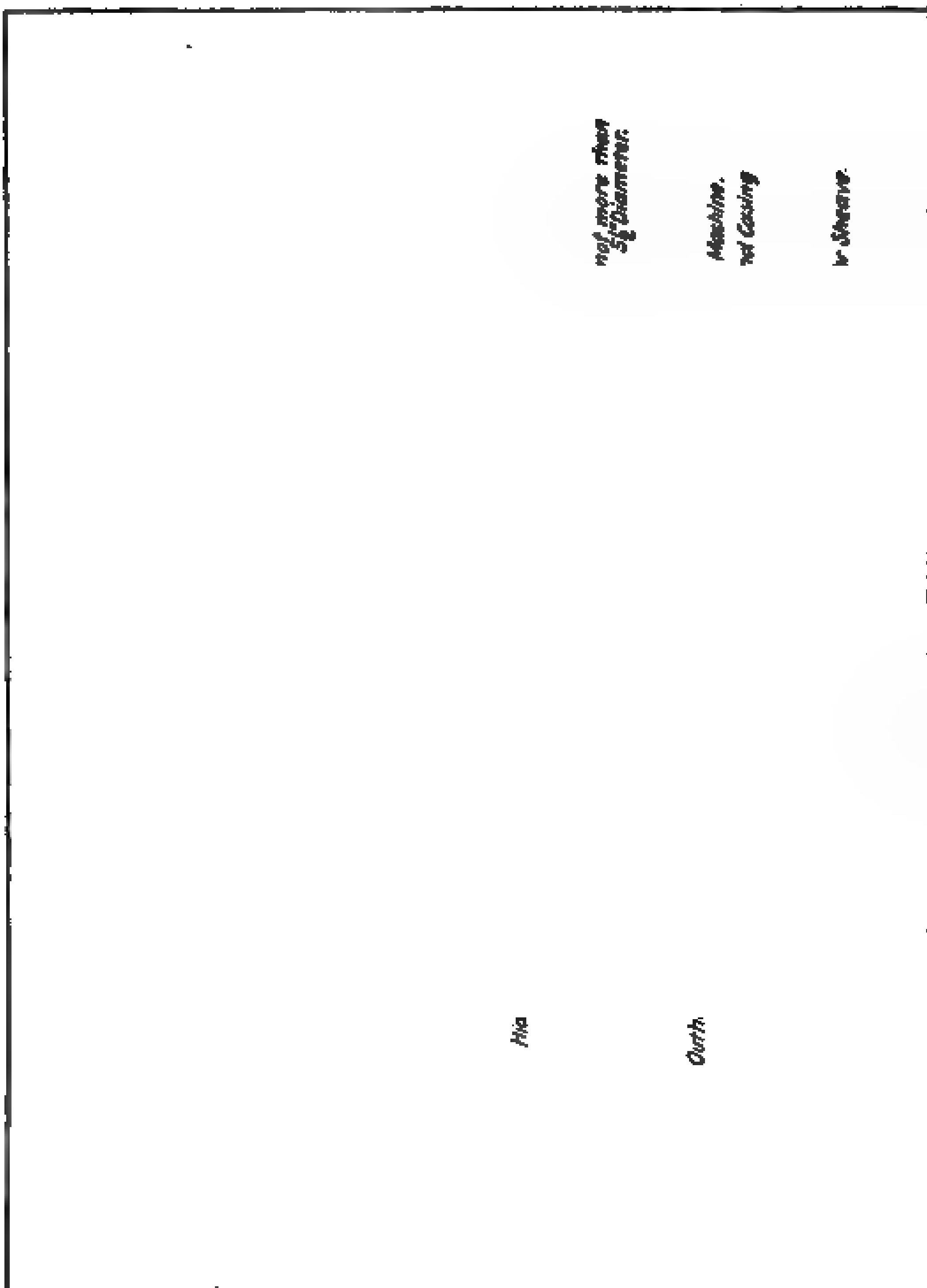
Plate No. 50.



KELVIN SOUNDING MACHINE, MARK IV.

Note.—The Motor-driven Machine is identical with this in all important details but with an electric-motor attached for reeling-in.

Plate No. 51.



NEW TYPE KELVIN SOUNDING MACHINE ON BRIDGE.

the dial, gives the approximate depth by mere reference to a standard "Speed and Depth Table."

Tubes are still used for perfectly accurate results, but the indication of the dial, which is instantaneously available, is found to be reliable within narrow limits.

2d. The use of a spar carrying a fair-lead and rigged out beyond the side, makes it practicable to mount the machine at any point along the beam. If mounted on the bridge, it is immediately under the eye of the officer of the watch, who has only to note the reading of the dial and refer to the Speed and Depth Table to get the depth immediately.

3d. In a special form of this type, known as the "Motor Sounding Machine," the wire is reeled in after a sounding by an electric motor which is a part of the machine. With this instrument soundings can be taken not only much more conveniently, but much more rapidly, than when working by hand.

Unquestionably the most important of these improvements is that which gives the depth by the amount of wire run out. With the older types of this machine it was possible for an experienced operator to make a fair estimate of the depth from the length of wire which ran out for a given speed of the ship. But the tension on the wire, due to friction of bearings and methods of manipulation, was subject to considerable variation, and probably few navigators attached sufficient importance to this record to give much attention to standardizing conditions.

In the Mark IV machine, every effort is made to reduce friction and other variable factors, and an **automatic friction brake** is fitted to the drum for the purpose of keeping a constant tension in the wire. This brake consists of a cord passing over a V-shaped groove on the side of the drum and carrying a weight at each end. The weight on one end is constant at 1 lb.; that on the other end varies with the speed.

A "**Speed and Depth Table,**" constructed experimentally by a British cruiser, is issued by the manufacturers. This table is reproduced below. It extends only to 13 knots' speed and to 45 fathoms' depth.

If this table is to be used, care must be taken to use the standard fittings which come with the machine. Any ship may, however, construct a table with fittings of her own, taking advantage of opportunities which present themselves from time to time for

sounding in varying depths, and at varying speeds, using tubes to record the correct depths and carefully tabulating all features connected with the soundings.

It is important that the number of fathoms of wire run out should be noted *the instant the wire slacks,* and not after the hand-brake has been applied, as a few fathoms of wire may run out while the brake is being applied.

SPEED AND DEPTH TABLE.

Machine, Kelvin's Mark IV.
Sinker, Kelvin's M.C.I. with lead core, weight 24 lbs. Plaited Hemp Line, 12 ft. long.
Wire, Seven Strand.
Automatic Brake Weight, 6 lbs.
Wire led through Kelvin's carrier and block.
Guard Tube, Seized on 8 ft. above eye of sinker.

APPROX. VERTICAL DEPTH.	FATHOMS OF WIRE RUN OUT. Speed in Knots.					APPROX. VERTICAL DEPTH.	FATHOMS OF WIRE RUN OUT. Speed in Knots.				
	6	8	10	12	13		6	8	10	12	13
5 Fms.	6½	7½	9½	10½	14	25 Fms.	32½	38	45	51	54½
6 "	7½	9	11½	13	16	26 "	33½	39½	46½	53	56½
7 "	9	10½	13½	15	18	27 "	35	41	48½	55½	58½
8 "	10½	12	15	17	20	28 "	36	42½	50	57½	61
9 "	11½	14	16½	19	22	29 "	37	43½	52	60	63
10 "	13	15½	18½	21½	24	30 "	38½	45	53½	62	65
11 "	14½	16½	20	23	26	31 "	40	46½	55½	64½	
12 "	15½	18	21½	25	28	32 "	41	48	57	67	
13 "	17	19½	23	27	30	33 "	42½	49½	59	69	
14 "	18	21½	25	28½	32	34 "	43½	51	60½	71½	
15 "	19½	23	26½	30½	34	35 "	45	52½	62½	74	
16 "	20½	24½	28	32½	36	36 "	46	54			
17 "	22	26	30	34½	38	37 "	47½	55½			
18 "	23	27½	31½	36½	40	38 "	48½	57			
19 "	24½	29	33½	38½	42	39 "	50	58½			
20 "	26	30½	35	40½	44	40 "	51	60			
21 "	27½	32	37	42½	46	41 "	52½				
22 "	28½	33½	39	45	48	42 "	54				
23 "	30	35	41	46½	50	43 "	55				
24 "	31	36½	42½	49	52	44 "	56½				
						45 "	58				

Notes as to Fittings.

The length of the outrigger should be from 30 to 40 feet, varying with the length of the ship.

The spar should be attached to a stanchion or to the rail by a gooseneck or swivel admitting of free play in all directions, and steadied by a topping-lift and forward and after guy.

Sliding in and out on the spar is a cylindrical carrier, with a pulley for the wire. The carrier is moved out and in by hauling-lines, the outhaul reeving through a sheave in the end of the spar.

The pulley has free play in all directions.

The stray line between the sinker and wire should be not less than 9 feet. The guard-tube is seized on to this line 3 feet above the eye of the sinker.

Two weights are supplied for use on the end of the automatic brake-cord; one of 6, the other of 10, pounds. The lighter is used for speeds up to about 13 knots, the heavier for higher speeds.

The same weight must always be used for the same speed.

Both the brake-cord and the groove in which it works must be kept in good condition, and the brake-weights and the tubes kept clean and lightly coated with oil.

A reel, and fittings for attaching it to the machine, are supplied and the wire should occasionally be run off onto this reel and examined and oiled, after which it is reeled back on its regular drum.

If a defect is discovered in the wire it must be cut out and the wire spliced.

SOURCES OF ERROR.

1—Change of Barometric Pressure.

No correction is needed if the barometer is standing at a height between 28¾ and 29½ inches.

If the barometer	stands at	29¾	add 1	fathom	in	40.
"	"	30	"	"		30.
"	"	30½	"	"		20.
"	"	31	"	"		15.

2—Temperature.

The assumption is made that the air enclosed in the tube is at the temperature of sea water at the moment it is immersed. Should the tube, however, have been exposed for any length of time to, say, sunshine, the enclosed air may be very much warmer than the temperature of the sea, and a considerable error in the reading may thus occur. No definite correction can be given for this, but the error is obviated by keeping the tubes immersed in a bucket of sea water for a few minutes before use so as to cool them down to the temperature of the sea.

It will be well to remember the following rule: When a Sounding Tube is removed from the sheath after use it should contain no water, or, at most, a very small bubble of water. If it be properly cooled to the temperature of sea water before use the whole volume of water forced into the tube when at the lowest depth will be expelled by the air compressed in the tube on being brought again to the surface. If, however, the tube be warmer than the sea water a greater or less amount of water will be

found inside the tube after removal from the sheath. This simple check forms a ready guide as to whether the Sounding Tube was properly cooled before use.

3—Bubbles of Water in Tube before Immersion.

It is of importance to see that the Sounding Tube is absolutely free from any bubble of water before use. For instance, should a warm tube be placed mouth downwards in a bucket of water for the purpose of cooling the former, the enclosed air will contract and draw up a bubble of water into the tube. If the tube be now placed in the sheath for sounding before shaking out the bubble of water it is clear that the tube does not contain its full volume of air, and the error of the reading will be just as great as if the tube had never been cooled in the first instance.

To guard against this error it is advisable to immerse the tubes in a bucket of water with the open end of the tube uppermost, taking care, however, that the depth of water is at least 1 inch less than the length of the tube so that there is no risk of water entering through the open mouth of the tube.

If a bubble of water be contained in the tube and it be turned upside down, or if the tube be inserted in the sheath upside down, the indication on the chemically prepared surface will be entirely false.

BAD CUTS.

Complaints are sometimes received regarding indefinite cuts obtained from the use of Sounding Tubes. When a Sounding Tube is properly used the cut is perfectly definite and unmistakable. The principal causes for bad cuts are as follows—

(1) Allowing the line to over-run after the sinker has touched bottom. Should a considerable amount of over-run be permitted the sheath containing the Sounding Tube may lie horizontally on the sea bed which will probably result in a bad cut. The sheath is usually fixed about a fathom's length above the sinker so that a margin is allowed for over-run. This is found sufficient with careful handling.

(2) Too sudden an application of the Sounding Machine brakes. If the running out of the line be stopped with a violent jerk the weight of the sinker at the end of a long flexible line of steel wire is likely to set up an oscillation causing the water inside the Sounding Tubes to jump and the cut to be erratic. The brake of the Sounding Machine should be applied by means of

the handle gradually and evenly, not jerkily. With a small amount of experience this is very readily achieved.

(3) After winding in the sinker allowing the sheath containing the tube to be laid down on deck horizontally before removal of the tube. In such case any drop of water which may remain in the tube is likely to run up the sides of the tube disfiguring the cut. **The sheath and tube should be held vertically until the tube is removed and the depth read off on the fathom scale.**

THE TANNER-BLISH SOUNDING MACHINE.

This is another type of machine which is much used in American ships. It resembles the Kelvin Machine in principle but differs from it in the sounding tubes used. The Kelvin tubes, as has been explained, are coated on the inside with a chemical substance which changes color where it comes in contact with sea-water. The Tanner-Blish tubes are ground on the inside, so that they show as clear glass wherever they are wet. Thus they present as clear a *cut* as do the Kelvin tubes at the point to which the water has been forced by the pressure due to the depth. The tube is dried after using and is then ready for another cast, which of course results in marked economy so far as the expenditure of tubes is concerned.

The Tanner-Blish tube is a slender tube of glass, 24 inches in length, with small uniform bore, the walls of which are ground or clouded, causing them to appear translucent when dry, and clear when wet. Hence the dividing line between the translucent or dry and the clear or wet surfaces indicates the high-water mark in sounding. The tube is ground spirally to counteract the effect of capillary attraction, but the bore is not changed in size or form by the process of clouding.

The upper or ground end of the tube is capped during the process of sounding, the lower end remaining open; hence the column of air confined within the bore is compressed by the increasing pressure of the water which penetrates it in proportion to the depth to which the tube is sunk.

The lower end of the tube is left unground for several inches to insure the cap being placed always on the same end.

After sounding remove the tube from the shield, lay it in the groove of the scale and read the depth in fathoms at the high-water mark. The reading will be facilitated if the light strikes the tube against a dark background.

To dry a tube in readiness for another sounding remove the cap, put the lower end to the lips and draw air through the bore with long steady inhalations, filling the lungs two or three times, or as often as it may be found necessary, taking care not to blow into it, as the moisture of the breath will delay the operation.

A dry tube will be recognized by the translucent whitish color of the clouded portion, free from dark wet spots, and in sharp contrast to the transparent unground end.

Foreign matter accidentally introduced into the bore may cause the high-water mark to become indistinct; a few drops of alcohol allowed to run back and forth through it two or three times will remove the difficulty; rinsing with fresh water will usually answer the purpose.

Tubes actually in service should remain capped between soundings, as they will be impervious to moisture while so protected.

The rubber cap, with which the upper end of the tube is closed, is made from a special quality of rubber, which is not affected by climatic extremes of heat and cold, and retain its elasticity under the varying conditions of service.

The cap is slipped on and off at pleasure, and when removed the tube is open throughout its length, allowing free circulation of air, which is essential for the quick and thorough drying of the bore.

To prepare a new tube for sounding remove it from the packing cylinder, strip off its paper wrapping by unwinding it from the end that is twisted, take a rubber cap from the receptacle in the head of the packing cylinder, slip it on the upper end of the tube and put the latter into the shield.

4—Submarine Signals. (Plate 52.)

This is a system, recently devised, for transmitting sound signals through the water, and receiving them by special instruments on shipboard, the receiving arrangement being of such a nature as to admit of determining, at least approximately, the direction from which the sound is received.

The rapidly increasing use of these signals is doing much to reduce the dangers connected with navigating in fog. Until quite recently the application of the system was restricted to the marking of *fixed* points, such as lighthouses and light vessels; this for the reason that the difficulties connected with the use of the *sending* apparatus on rapidly moving vessels had not been over-

Plate No. 52.

Transmitte Case in Hold of Ship.

(Connected Electrically with Receiving Telephones in Pilot-House.)

Direction Indicator and Receiving Telepnone.

SUBMARINE SOUND SIGNALLING APPARATUS.

Old Type.

come. Within the last two years there has been perfected a device, the "Fessenden Oscillator," which makes it possible for a vessel moving at high speed to send signals as well as to receive them,—the same instrument serving for both purposes, though not for both at the same time.

It is manifest that this instrument puts into the hands of seamen a new and very valuable means of safety, especially in thick weather; and safety not alone from fixed dangers to navigation, but from collision with other vessels.

It furnishes also a new method for the interchange of signals between ships,—a method which has great possibilities of usefulness for men-of-war and for vessels in need of assistance.

The power to determine the direction from which the sound waves are received is a very valuable one.

In its original and simplest form,—the form which admits of both sending and receiving from a fixed station but of receiving alone from a moving station,—the system is as follows:

A **bell**, immersed as far as is convenient below water, is so placed as to mark a danger or a point of importance in piloting, and is automatically sounded at certain intervals with a characteristic signal which fixes its identity. The sound of the bell is transmitted through the water, and experiments show that it can be heard *without instruments* at a distance of several miles, by a listener whose ear is held against the inner skin of a ship below the water-line. It seems to be established that even with this crude arrangement for receiving, sound-signals transmitted through the water are superior in range and reliability to those transmitted through the air. With the special apparatus shown in Plate **52** for receiving the sound and transmitting it, magnified, to the ear, the range of audibility is from 4 to 10 miles, depending upon conditions;—that is to say, upon the speed of the ship and the bearing of the bell. High speed is to some extent unfavorable, doubtless because the wash of the water along the side interferes with the sound. The bearing of the bell with reference to the ship's head determines the angle at which the sound-waves strike the receiver, the result being that a signal on the beam can be heard much farther than one which is forward of or abaft the beam.

If the submarine did nothing more than to announce *with certainty* the proximity of the danger which it marks, it would be a very valuable aid to navigation. But it does much more than

this. It fixes the *direction* of the danger within narrow limits; and in those waters—common enough on irregular coasts—where the zones of two or more signals intersect (or will intersect when the use of the system becomes more general), the position of the ship may be plotted with considerable accuracy by the crossing of the lines of bearing, exactly as in the case of visible bearings, though not with the same degree of accuracy.

The receiving apparatus (Plate 52) consists of a small iron tank attached to the side of the ship, wholly on the inside, and filled with salt water. In this tank is a delicate receiver which takes up the sounds as they come to it through the water and transmits them through an electric circuit to a telephone in the pilot house or on the bridge.

A switch admits of throwing in either the starboard or the port receiver. If it is desired to listen to both sides, the receivers are thrown in alternately, by a movement of the switch. If the sound is heard more clearly in the starboard than in the port receiver it is known that the signal lies to starboard. If it is equally clear in both receivers, the signal is directly ahead (or astern). If, as the ship swings, the sound grows fainter in one transmitter and clearer in the other, the signal is drawing toward that beam from which it is heard more clearly. When it is at a maximum it is approximately abeam.

A signal which is decidedly on one side of the ship will hardly ever be heard through the opposite receiver; but when only a little on one bow, it can usually be heard in the receiver on the opposite bow. Thus, as has been explained, a signal which is nearly ahead and not very far distant may be heard through both receivers.

If the signal is more distant, the sound will be lost, even in the near receiver, as the ship's head swings up to it, and will not be picked up on the other side until perhaps a point or more on the bow. In this case, its bearing may be taken as approximately midway between the heading on which it is lost and that on which it is again picked up.

A ship picking up a signal through the starboard receiver knows that the bell lies to starboard and in all probability forward of the beam. The sound may be expected to grow clearer until the bell is abeam, and then to grow fainter as it draws abaft.

If its approximate bearing is wanted before it comes abeam, the course may be changed toward it and the speed reduced if

necessary. The bearing is then determined as has been explained above.

While it is not claimed in the present development of the system that the signals can be heard beyond about 5 miles, there are many cases recorded in which they have been heard at two and even three times this distance, and in one well authenticated case they were heard slightly more than 26 miles. Vessels carrying their receivers well below the water-line can hear to a greater distance than others. A vessel at rest hears farther than one that is moving. And certain configurations of the bottom seem to have the effect of gathering up and concentrating the waves of sound and transmitting them to a distance, like a megophone.

It is evident that the receivers of a ship can pick up other sounds than those from a bell and that they may thus be useful, for example, in giving notice of the proximity of another ship whose propellers are turning over. The noise of the propellers might in many cases be heard much farther than a fog-whistle. When the arrangements for *transmitting* from vessels underway have been perfected, vessels in a fog will be able to communicate at much greater distances than at present, and there seems no reason why there should not be devised some plan—perhaps by revolving the receiving instrument—for determining the direction from which the signals come, without the inconvenience and delay incident to such changes of course as have been described in connection with piloting.

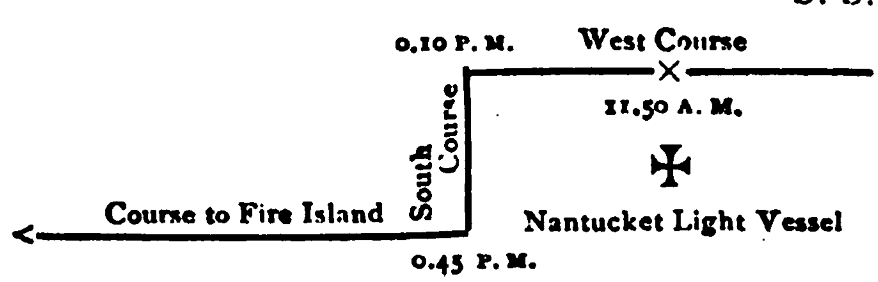
The following is an interesting example of a practical application of the system:

Approaching Nantucket light vessel on a west course in a dense fog with a light S. S. E. breeze and smooth sea on May 5, 1906, we heard the submarine signal very slightly on our port side in a distance say about 4 to 6 miles. When the sound ceased at 0.10 p. m., I put the vessel on a South course and heard the signal then again till 0.45 p. m. I was then sure that I had the light vessel to the eastward and put my course direct for Fire Island light vessel. During all the time we never heard a single sound of the Nantucket light vessel's steam whistle.

Yours very truly,

(Signed) CAPT. R. SAURMANN,

S. S. Amerika.



The following notes are from the official report of tests of the Submarine Sound Signal Apparatus conducted by the British Admiralty in 1906. They are reproduced here as embodying at once a description of the system, and an illustration of the method of using it, together with conclusive evidence of its value.

Sending Apparatus.

H. M. S. *Spanker* was fitted for sending signals by means of a submarine bell as follows:

The ship being at anchor, the bell was lowered 20 feet below water from the cathead; it weighs about 300 lbs. and consists of two parts. The upper part contains the mechanism which operates the striker or tongue of the bell; it is bolted to the bell with an india-rubber disc between to prevent the contact of the metal deadening the sound vibrations.

Receiving Apparatus.

H. M. S. *Antrim* was fitted with two receiver tanks, placed one each side about 20 feet below the water-line in the fore part of the ship, 53 feet abaft the foremost perpendicular.

When in place the tanks are filled with salt water and microphones are placed in them; each microphone is connected separately by insulated wires to a switch-box in the chart-house; the switch-box has two ear-pieces or listeners connected to it by short leads of wire.

The person using the listeners can hear sounds caused by sound-waves which may strike the starboard side of the ship, or by working the switch he may listen to those striking the port side, but it is rendered impossible for him to hear sounds coming from both microphones at once.

At 5 miles distance the *Antrim* turned under starboard helm, steaming 5 knots, to present her port side to the *Spanker*: the bell was heard all the time, getting clearer and more distinct as it drew abeam.

The helm was kept on so as to bring the *Spanker* across from the port to the starboard bow.

Captain Oliver listened with the ear-pieces connected to the port microphone, the sound getting gradually fainter from the time the bell was 2 points on the port bow until right ahead, when it was not audible. The switch was then moved, and the starboard microphone connected to the ear-pieces; the bell was again audible when half a point to the starboard bow, the sound getting louder and louder as the *Spanker* came more and more on the bow.

The *Antrim* was then swung under port helm to bring the *Spanker* across the bow again, and Captain Everett tried to locate the bearing of the *Spanker* without looking to see how the *Antrim* was heading. When he commenced, the *Spanker* was two points on the *Antrim's* starboard bow, and the *Antrim* was slowly swinging to starboard; using the starboard microphone the bell was heard distinctly at first, and it gradually got fainter and fainter. The direction of the ship's head by compass was noted when Captain Everett said the sound was inaudible, and the port microphone was at once switched on, when he immediately heard the bell again.

At the time the sound was lost with the starboard microphone, the *Spanker* was right ahead.

This shows that at a distance of 5 miles the submarine bell could be heard and its direction located with certainty, and this is a distance beyond the certain range of any of the aerial sound signals in use by light vessels in fog.

When at the 5 miles distance an officer stationed below was able to hear the bell by placing his ear against the ship's side below the water-line.

Experiments at Ten Miles' Distance.

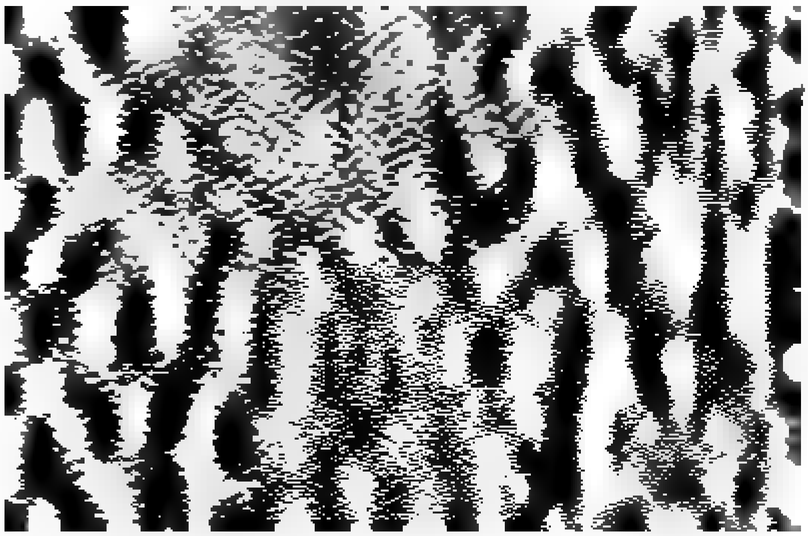
When this distance was reached, the *Antrim* was turned to bring the *Spanker* to bear on the port beam, going 14 knots; the bell was heard when the *Spanker* bore two points abaft the port beam; when it was abeam and a little before the beam, the note was very clear and musical. Speed was then reduced to 5 knots, and the ship allowed to swing slowly up to port to bring the *Spanker* across the bow as in the previous experiment. Captain Oliver, standing in such a position that he could not tell how the *Antrim* was heading, listened with the port microphone connected; the sound was loud at first, gradually becoming fainter; when he lost it, the direction of the ship's head was noted by another observer and the starboard microphone immediately switched on, and as soon as the sound was audible again the direction of the ship's head was again noted.

The result was, that the sound was lost with the port microphone when the Spanker was half a point on the port bow and picked up with the starboard microphone when she bore half a point on the starboard bow, the mean of the two being the exact bearing of the Spanker.

With the apparatus which has been described, a ship can receive signals but cannot send them. The Submarine Signal Company has long been engaged in an effort to develop a system which should make sending possible from a moving ship. The Fessenden Oscillator, already mentioned, has solved the problem. (Plate 53.) This oscillator is both a sending and a receiving instrument. As a sending instrument it greatly surpasses the submarine bell both in power and in speed of operation. It can be readily mounted on shipboard and produces signals equally effective whether the vessel is in movement or at rest, gives a signal of full power for any desired time (as contrasted with the bell, the vibrations of which lose their power rapidly), and can start or stop almost instantaneously.

As a receiving instrument it is quite as effective as the microphone used in the earlier submarine signalling apparatus.

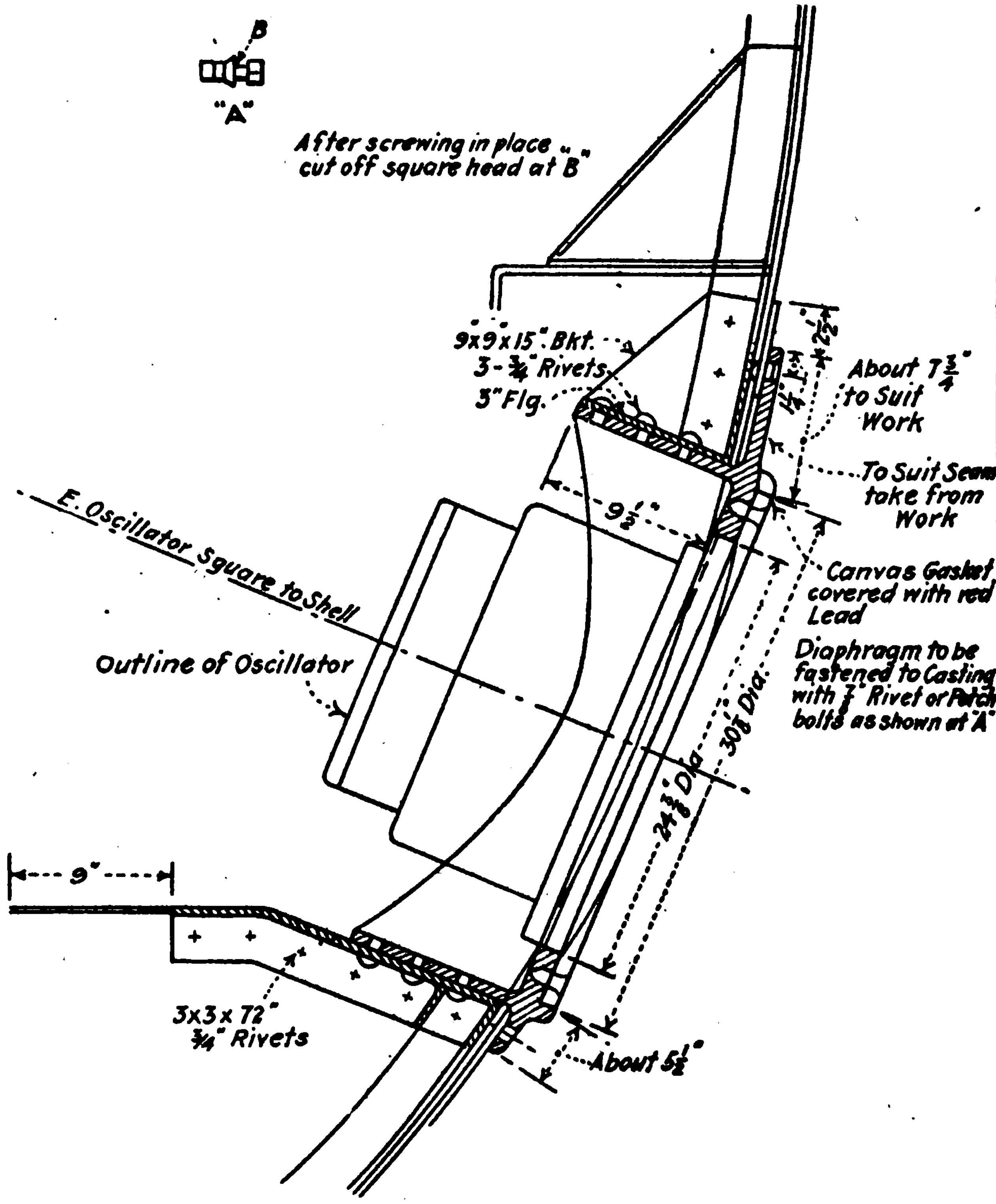
It is unnecessary to dwell upon the advantages connected with a system like this which makes it possible for a ship to interchange signals with another ship or with a shore station, and this



1 Vibrating Diaphram
2 Tubular Movable Conductor (Copper)
3 Flexible Discs, Keyed to Steel Rod 9.
4 Coil of Electro-magnet. Direct Current
5 Electro-magnet
6 Air-tight Cover of Oscillator
7 Cylindrical Soft Iron Core
8 Coil enclosing Copper Cylinder Alternating Current
9 Steel Rod Controlling movement of Diaphram, 1.

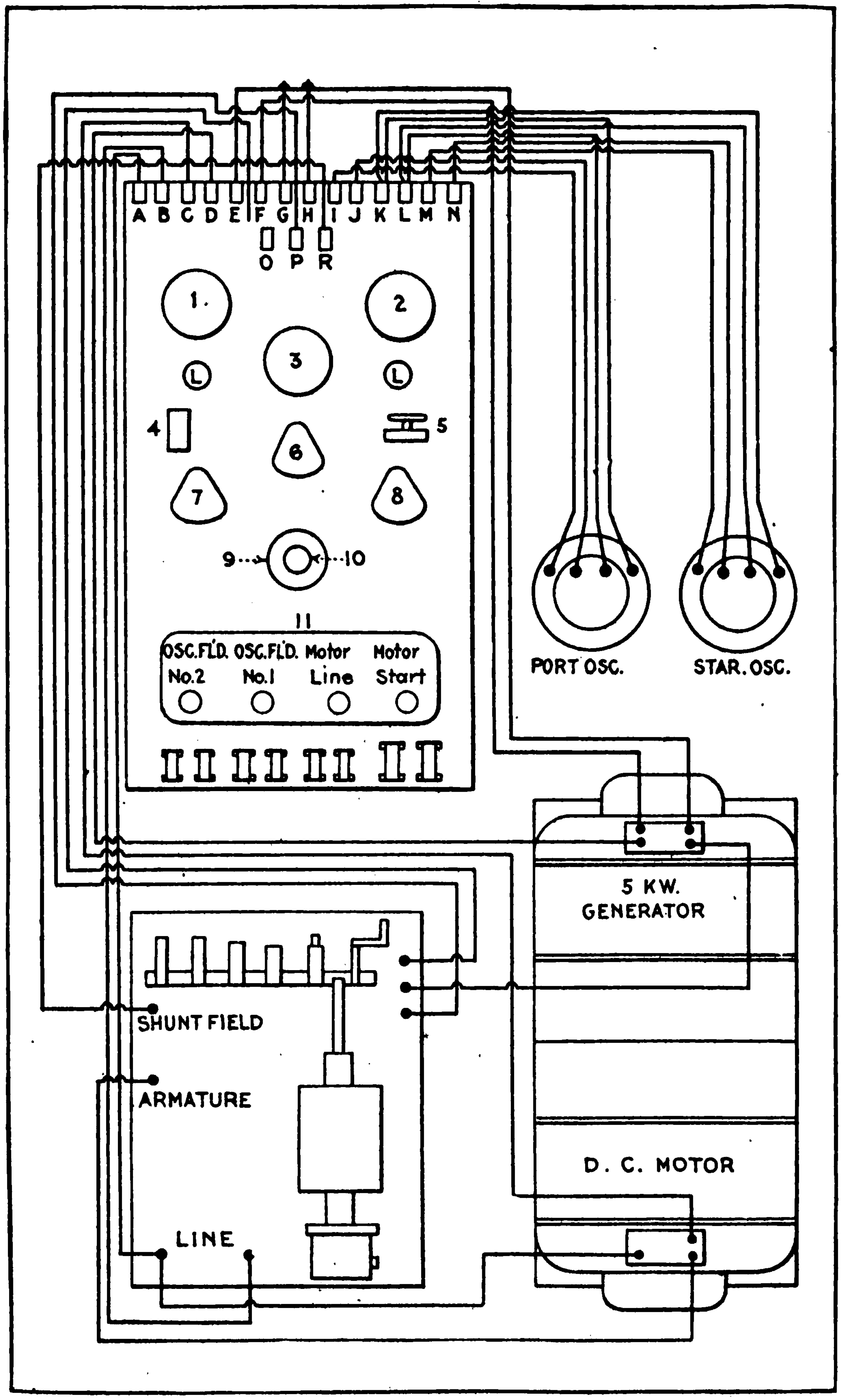
FESSENDEN OSCILLATOR

Plate No. 54.



SECTION THROUGH OSCILLATOR

OSCILLATOR ATTACHED TO SKIN OF SHIP.



SWITCHBOARD SUBMARINE SIGNAL SYSTEM.

without regard to weather conditions, "zones of silence" or "interference."

Like the microphone tanks of the earlier signalling apparatus, the box containing the oscillator is bolted to the inner skin of the ship well below the water-line, but whereas the tanks containing the microphones of the earlier system were filled with water, the box containing the oscillator is filled with air, and, as it is of the first importance that this air should be dry, it is given a pressure of twenty-five pounds to the square inch before the box is sealed up.

The oscillator is attached to the skin of the ship in such a way that its diaphragm actually constitutes a part of the ship's plating, a circular hole being cut in the side to admit of this. Plate **54**.

The action of the oscillator is in many respects similar to that of a telephone receiver. The diaphragm is vibrated, as in the telephone, by rapid variations in the polarity of an electro-magnet. But as the diaphragm is enormously larger and thicker than that of the telephone, its operation calls for the use of powerful electric currents. The standard type takes a direct current of seven amperes through the main magnetic coil and an alternating current of eleven amperes through the core. The instrument is operated from a switchboard shown on Plate **55**. Sending is done by an ordinary telegraph key; receiving, by telephone receivers.

The method of locating the direction of a signal received is exactly the same as with the earlier microphone system which has been fully described.

There is every reason to believe that the oscillator system will before many years be required as a part of the safety outfit of every seagoing vessel.

CHAPTER VII.

BOATS.

§1.

Boats designed to be carried on shipboard are subject to many requirements connected with lowering, hoisting and stowing, which define their characteristics within narrow limits, especially as regards their size and weight. The boats of a merchant vessel are intended almost exclusively for saving life under circumstances of emergency, when they must be handled by a small number of men and usually under conditions of more than ordinary difficulty. It is therefore as important for them to be light and handy as to be roomy and seaworthy. The boats of men-of-war are used for a great variety of purposes, and in design are usually a compromise between conflicting demands.

In considering the type of boat most desirable for ship's use, a distinction should be made between the general service of the ship, whatever that may be, and the specific object of saving life in the case of a man overboard or of a call for assistance from another vessel in distress. For these last-mentioned objects and other similar ones, calling for the sudden lowering of a single boat, a type is needed which shall be exceptionally light, handy, and, above all, buoyant and seaworthy. It will be generally admitted that the type which best meets these requirements is the "**whale-boat**" of the New England whaling ships, which is quite a different thing from the boat commonly known under the name of a "whaler" in other ships. The true whale-boat has moderate beam, a long rather flat floor, an easy turn to the bilge, a very bold sheer and *no deadwood* either forward or aft. This absence of deadwood results in a sharp rake to the stem and stern posts, which round boldly in to meet the shallow keel. The lines are considerably fuller at the bow than at the stern, and this leanness of the after-body is one of the most characteristic features of the type.

Fig. 1, Plate **56**, is taken from an actual New Bedford whale-boat, and is believed to be the first authentic drawing of such a

boat ever published. The planking of these boats is never more than one-half inch in thickness; and the seams, instead of being calked, are covered by a light batten run along them on the inside. The timbers, knees, stem and stern post, etc., are also very light; indeed, every effort is made to gain buoyancy by saving weight.

Of late years whale-boats have been built for sailing rather than for rowing, and as a consequence the center-board has come into use and has necessitated some changes in design, which, however, do not essentially modify the description given above.

The true whale-boat is single-banked and designed to steer by an oar, though a rudder is fitted and works fairly well in smooth water. It should always be fitted to the curved stern post—*not to a straight post made by filling in with deadwood*—as this filling-in destroys one of the most important features of the type. The lightness of these boats, coupled with their form, makes them so buoyant that they ride over the waves where other boats cut through. The comparative flatness of the floor, the shallowness of the keel, and the absence of deadwood, make them very quick in turning, especially when steering by an oar; and this characteristic, added to their remarkable buoyancy, fits them peculiarly for use in a surf. They sail badly on a wind (unless fitted with a center-board), the lack of hold upon the water resulting in excessive leeway; but they do well off the wind and run well before a sea, and they can be rowed against a sea in which a deep cutter would be altogether helpless.

The crutch for the steering oar, which in navy boats is shipped at the very stern, is, in whaling, carried on a bumpkin projecting from the quarter of the boat. This brings it to one side of the man who handles it, and gives him much freer control than he could otherwise have.

Fig. 5, Plate **56**, shows the whale-boat of the U. S. Navy.

The whale-boat is not well fitted for the general purposes of a man-of-war, but could be perfectly adapted to the needs of the merchant service by certain modifications in the direction of carrying capacity. The boats commonly used by merchant vessels are "double-enders," and to this extent resemble whale-boats, but beyond this they have little in common with the type that has been described above, and certainly they have few of its ad

Plate No. 56.

Fig. 1

Fig. 4

Fig 5

Fig .

Fig. 6

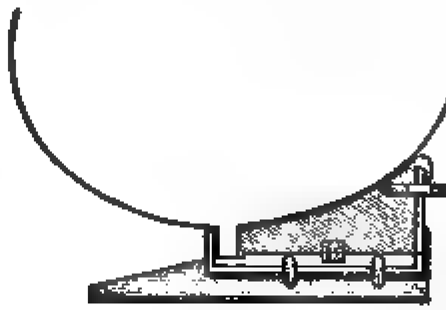
Lines of a New Bedford "Whaleboat."
Sheer, Half-Breadth and Body Plan.

29 Ft. Whaleboat
Sheer Half-Breadth and
Body Plan.

WHALEBOATS

Plate No. 57.

New England Dory
Fig. 1



Stowing Boats
("Kaiser Wilhelm der Grosse")
Fig. 3

Carvel and Clinker Work
Fig. 2

Fig. 4
Hook Engaged
(One plate removed to show details)

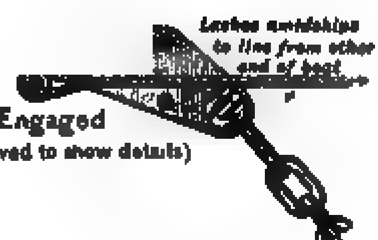
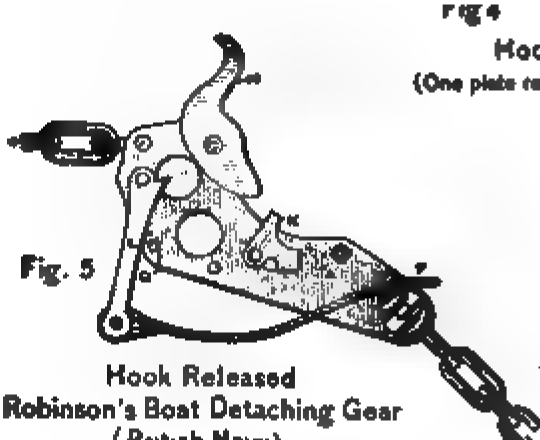


Fig. 5



Hook Released
Robinson's Boat Detaching Gear
(British Navy)

BOATS AND THEIR FITTINGS.

suitable characteristics, being apparently designed in many cases merely to meet the requirements of the laws to which they must conform.

The English law on this subject recognizes the following types of boats and specifies how many shall be carried by vessels under various circumstances.

"Section (A). A life boat of whale-boat form having one (1) cubic foot of air casing for every ten (10) feet of capacity."

"Section (B). A life boat of whale-boat form in which half of the buoyancy must be provided on the outside of the boat. Inside and outside buoyancy together to be equal to the buoyancy of the (A) boats."

"Section (C). A life boat having only half the total buoyancy of boats (A) and (B). Of this amount, half must be fixed on the outside of the boat."

"Section (D). A properly constructed boat of wood or metal."

"Section (E). A boat of approved construction, form and material, and may be collapsible."

The buoyancy referred to as on the outside of the boat is usually given by cork arranged in the form of a fender around the gunwale outside. The inside buoyancy is given by airtight tanks.

Collapsible boats, of which the best known type is the *Berthon*, are carried by many small ships, but are not often adopted for large ones. A type of "semi-collapsible" boat is carried by many steamers and has much to recommend it. It has a raft bottom, lightly but strongly built, with water-tight compartments in which provisions may be stowed.

There are many situations at sea in which a small, light boat like the "**dory**" of the New England fishing banks would be extremely useful (Plate **57**, Fig. 1). These boats may be launched in a moment by one or two men and when properly handled are wonderfully good sea boats. Several of them can be stowed in a "nest," one within the other, and occupy very little room.

Metallic boats are preferable to wooden ones when they are to be carried in such positions that they are of necessity exposed to excessive heat and moisture and when they are not to be often used. If subject to the sort of treatment that the boats of a man-of-war receive they would quickly be battered out of shape, and sooner or later punctured, when the problem of repair on shipboard would become a difficult one.

Life-rafts of the balsa or catamaran type are very useful and it is to be regretted that all ships are not required to carry a num-

ber of them. They can be transported easily from one part of the ship to another, and can be launched overboard at any point and by anybody. They give a hope of saving life under conditions such that a boat would be altogether useless.

THE BUILD OF BOATS.—There are in common use three systems of building for boats—the Carvel, Clinker (or Clincher) and Diagonal.

In Carvel building (Fig. 2, Plate 57), the planks lie alongside each other without overlapping, the seams being calked and payed. Where the build is too light to admit of calking, a narrow batten or riband is run along the seams inside, the calking being in this case limited to the garboard seams and the butting ends of the planks.

Where heavy boats are built on this system, a second layer of planking is sometimes used inside the frames.

In Clinker building (Fig. 2, Plate 57), the planks overlap at their edges like the clapboarding on a house, and are fastened to each other as well as to the frames. As the planks thus support each other, this system has greater strength for a given weight than Carvel building and the frames can be placed farther apart. On the other hand, the planks are liable to split along the line of fastenings, and repairs called for by this or other injuries to the boat are made with some difficulty because of the necessity of removing several planks to repair one. The seams are not calked, the swelling of the planks causing them to bind tightly upon each other. To keep them tight, the boat should be put in the water frequently, or, if that is impracticable, well wetted with a hose from time to time.

In Diagonal building, the planks run diagonally at an angle of 45° from the keel to the gunwale and two thicknesses of planking are used, at right angles to each other. No frames are needed. This is a strong system of building, but necessarily a heavy one. As a rule it is used only for launches and other large boats carrying heavy weights.

The Carvel and Diagonal systems are sometimes combined, two layers of planking being used, one carvel laid, the other diagonal.

CLASSIFICATION OF BOATS.—Boats are single- or double-banked, according as they carry one or two oarsmen on each thwart.

The boats of a man-of-war are classified as follows:

Launches.—These are large, heavy boats of great beam, flat floor and rather shallow draft, designed for carrying stores and men, and fitted to mount one or more light guns.

United States Naval launches are now made with a length of 50 feet and fitted with motor propulsion sufficient for a speed of from six to eight knots. They carry one hundred and fifty men with safety, and are rapidly replacing other ships' boats for general work in port.

Cutters.—These are smaller than the launches, designed for the same general purpose, but used, in addition, for the miscellaneous work of the ship. They are narrower than launches and of deeper draft. The "pinnace" of the English Navy is a large cutter.

Cutters are fast being displaced in men-of-war by the motor launches described above.

Whale-boats.—Double-ended boats resembling more or less closely the whale-boat already described.

They are used, like cutters, for the miscellaneous service of the ship, but are rather more convenient than cutters for passenger boats, and much more convenient for life-boats.

Whale-boats have practically disappeared from the capital ships of the United States Navy except for life-boats, for which purpose they are likely to continue in use indefinitely.

Galleys and Gigs.—The galley of the English Navy is a long, narrow, rather deep, single-banked boat with a square stern. This type of boat was formerly used almost exclusively in all navies for the gigs of commanding officers, but is being displaced by whale-boat gigs, which are in all ways to be preferred.

It should be noted that the term "galley" describes the form of the boat, while "gig" has to do with the purpose for which it is used.

Dinghys.—These are small handy boats, with square sterns, pulling usually four oars, used for transporting marketing, servants, etc.

Jolly-boats, Yawls, Wherries, etc., are small, lightly built boats pulling two or four oars (usually double-sculls) for general utility.

A **Barge** is the personal boat of a flag-officer. In modern navies it commonly takes the shape of a large, fast and comfortable motor boat or steam launch.

Steam-launches, Steam-pinnaces, Steam-cutters, and **Steam-whalers** are boats having the general characteristics already described, but fitted to run by steam, and, naturally, more strongly and heavily built.

For full details as to United States Navy boats, see table in Appendix.

§II. THE STOWAGE AND HANDLING OF BOATS.

The arrangements for carrying and handling boats on shipboard as they exist at present are in most instances far from satisfactory. In the case of men-of-war there is perhaps little that can be done to improve matters (except in the type of davit used) as the exigencies connected with the placing and using of the battery to the best advantage establish limitations, in connection with which everything else is of minor importance. Men-of-war usually carry a few boats at davits along the side from the waist to the quarter, and others on an elevated deck or "gallows frame" from which they are either lifted by a heavy boom and swung over the side, or run out by means of traveling cradles to davits, where they are hooked on, hoisted, swung out and lowered. Whichever method is used, the process of getting them out is necessarily slow, and with the average man-of-war not even the most perfect drill and discipline could give much hope of saving life by these boats in case of sudden disaster. As life-saving in a man-of-war is necessarily secondary to many other considerations, this matter is not as important as in merchant steamers, with hundreds, or it may be thousands, of passengers and with small crews, often very inadequately drilled.

Many seamen contend that boats should be carried hanging at their davits and *swung out*, under all ordinary circumstances, and rigged in only in very bad weather. The fact that all well-organized steamers habitually carry one or two boats in this way is sufficient evidence that it is not impracticable, although the wear and tear upon blocks and falls would doubtless entail considerable expense.

Captain Mills of the steamship Westernland writes to the author in reply to the question whether he considers it practicable to carry the boats of an ocean steamer swung out. "Yes, I have carried this ship's largest boats (548 cubic feet) swung out in several heavy

Fig. 1 Mallory Davits.
Boat Inboard, Resting on Chock.

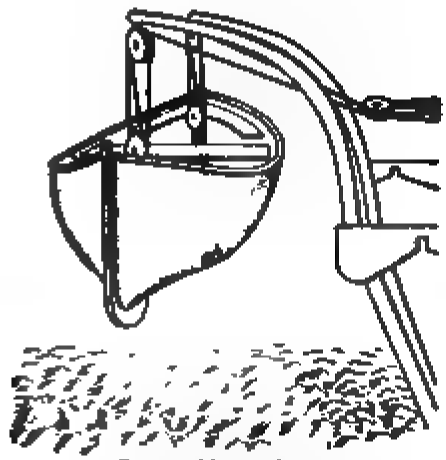
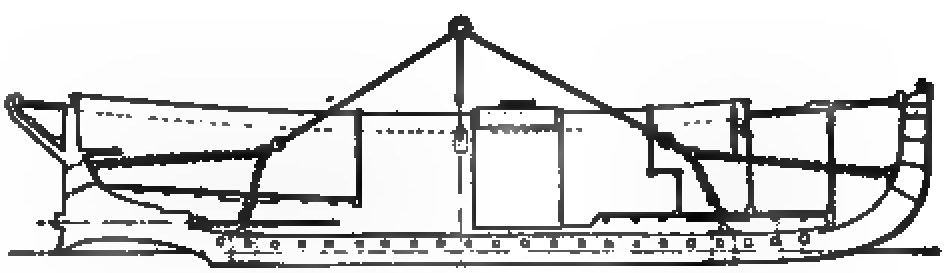


Fig. 2 Mallory Davits.
Boat Ready to Lower.



Slings for Hoisting a Heavy Boat.
(Steam Launch, United States Navy).
Fig 3

HOISTING AND STOWING BOATS.

gales and I think they are safer there than in chocks unless the vessel is very low in the water."

It should be stated that a majority of the officers to whom this question was put replied that they considered it impracticable to carry the boats in this way.

Whatever may be thought of the feasibility of this plan in general, there can be no question that all the boats of a passenger steamer should be cleared away and kept ready for lowering at certain times of exceptional danger; as, for example, when running through crowded waters in a fog.

As a general thing, the boats of merchant steamers are stowed in cradles on deck, where they are lashed and covered. Iron davits, curved and turning in sockets bolted to the side of the ship, are swung in to plumb the bow and stern of the boat, where the tackles from the davit-heads hook to ring-bolts. To get them out, the covers and lashings must be cast off, the boats lifted sufficiently to clear the cradles, and the davits swung out, one at a time, throwing the boat clear of the side and into position for lowering. This is not a difficult operation, nor necessarily a long one, if the boats are in good condition, the officers and crew cool and well disciplined, and the ship on an even keel. But such conditions as these are altogether unusual. As a rule, when the boats are needed in a hurry, neither the force nor the skill is available for lifting and swinging them out; and often the ship has a heavy list, making the difficulty of swinging out almost insurmountable.

In all cases where boats are stowed inboard the arrangements should be such that the boats need not be lifted to free them of the chocks. Where the davits are of the long curved type common on merchant steamers, this may sometimes be arranged by lashing the boats down, the lashings being fitted with slip-hooks, and then hauling taut the falls and belaying them with considerable tension. When the slip-hooks are knocked adrift, the tension on the falls, *coupled with the spring of the davits,* causes the boat to spring up clear of the chocks, which, if properly fitted, may then be turned down or otherwise cleared away.

In the plan shown in Fig. 3, Plate **57**, chocks are used on the inboard side of the boat only; an iron rod, running along the chock athwartships and bent up at its outer end around the keel, serving to hold the boat on the side to seaward. By knocking

the lashings adrift and turning down this rod, the boat is released in an instant.

The boat cover should be put on and secured in a way which will admit of casting it quickly adrift. The arrangement should be such that the cutting of a single line will release all the stops.

The boat should, if possible, be so placed under the davits that one end is ready to swing outboard at once, doing away with the necessity for launching bodily forward or aft.

Fig. 1, Plate 58, shows a form of davit which does away with the necessity of swinging out, the boat being habitually stowed outside the davits, although resting in chocks.

The falls are handier when coiled outside the boat, though this does not look as neat as to coil them inside. As already explained, they are kept taut enough to lift the boat slightly when the lashings are knocked clear, as well as to hold it if the cradles are washed away by a sea. They must be belayed to a cleat on the davits in order that the latter may swing freely, and it is important to make sure that they are belayed properly for lowering.

The cleats should stand out from the davits sufficiently to admit of lowering without jamming. This is a small point, but one which may be of vital importance.

The *Welin Davit* (Plate 59) overcomes many of the difficulties connected with the stowage and handling of boats.

Plate 60 shows the stowage of boats of a *Dreadnaught*.

Unless the boats and all their fittings are inspected frequently and thoroughly, there will be trouble when they are wanted. The custom in well-ordered vessels is to overhaul everything when preparing for sea and at regular and frequent intervals afterward; examining and oiling all parts of the disengaging gear and all blocks, swivels, etc. The boats are swung out before starting on a trip, and, if possible, lowered and hoisted to make sure that everything is in good working order. All the fittings and equipments of the boats (see list below) are inspected, water-breakers and bread-tins emptied, cleaned and refilled. Both at sea and in port, the boats are wetted frequently to keep the seams tight, but are never allowed to lie for long periods of time with water in them, as this rots the wood and rusts the fittings.

Plugs are habitually kept out, but especial care must be taken to insure that they are secured in such a way that they cannot be lost. At least two plugs should be provided for each hole and made fast in the boat by good lanyards.

Plate No. 59.

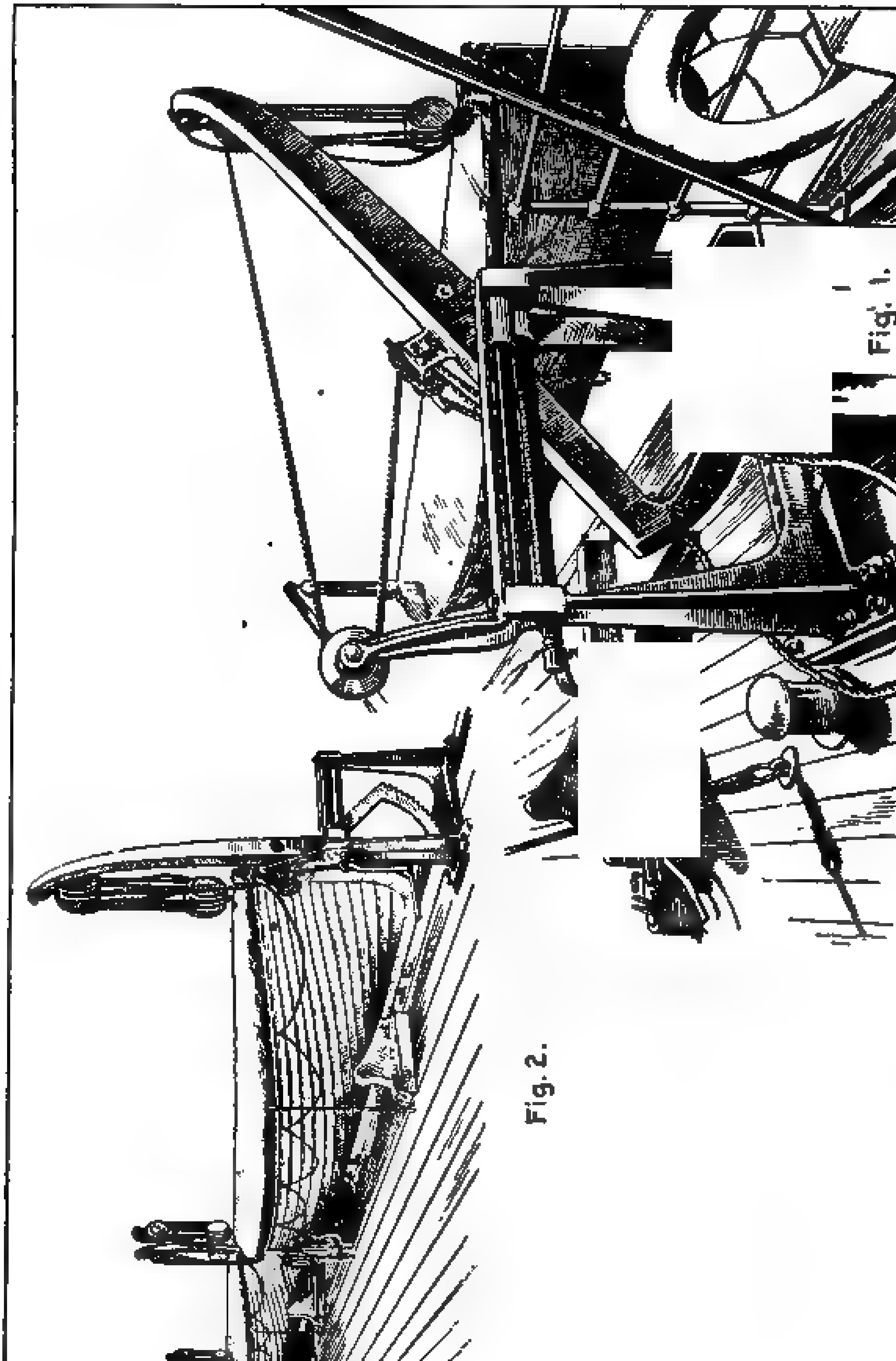


Fig. 1.

Fig. 2.

THE WELIN QUADRANT DAVIT.

Plate No. 60.

U. S. S. PENNSYLVANIA. VIEW LOOKING AFT

(Showing Boat Crane and Nesting of Boats.)

Several new devices for handling boats have been proposed quite lately and tested with promising results. There is good reason to hope that before many years great improvements in this line will be effected.

EQUIPMENT OF BOATS.

In preparing a list of articles for the proper equipment of a boat, it is necessary to consider the service for which the boat may be needed. One which is to be carried at the davits ready for lowering at a moment's notice to pick up a man overboard calls for a very different outfit from one which is never to be used except in case of disaster to the ship.

The following list includes all articles of ordinary equipment; others may be needed for special service of various kinds:

1. Set of oars, with spare for one thwart, with trailing lines if used.
2. Set of rowlocks, if used, secured by lanyards, with two spare.
3. Set of stretchers.
4. Plug, secured by lanyard.
5. Rudder and tiller, with lanyards.
6. Three boat-hooks.
7. Breaker, kept filled with good drinking water and carrying three days' supply for crew.
8. Fenders.
9. Compass.
10. Lantern.
11. Bucket.
12. Boat-box containing tools and material for meeting emergencies which may arise on distant service.

    Items 1 to 12 are, as a rule, kept in all boats at all times, except that the compass and lantern may be removed for safe-keeping when the boat is not to be used for some time.

13. Anchor, with chain or good line.
14. Sails and spars.
15. Tarpaulin.
16. Boats ensign, with staff.
17. Hand grapnels, with light chain or line.
18. Rifle and shot gun, with ammunition.
19. Provisions; usually bread and canned meats.
20. Night signals or other fire-works of some satisfactory kind for attracting attention at night.
21. Hand signal flags.
22. Crutch and steering oar for boats using them.
23. Life belts (life boats only).

    Items 13 to 23 are kept in the boat whenever they are likely to be needed.

There is a wide difference of opinion as to the articles which should be kept in boats, like those of a merchant steamer, which are likely to be used only in case of abandoning the ship.

The English Board of Trade rules require, among other things, sails and spars, and a sea-anchor. The insistence upon sails and spars clearly contemplates the possibility of a trip of some length after leaving the ship. No doubt such trips have been made by boats under sail, but in a great majority of cases the space occupied by the sails and spars could be utilized to better advantage for passengers, even if the boat were reduced to waiting helplessly for a passing vessel. A sea-anchor would be useful in a gale, but need only be carried if sails are omitted, as these two would never be wanted at the same time and the sails and spars lashed together (with sails loosed) make a perfectly efficient sea-anchor. Water and provisions are very important here.

Life-Boats. Probably no one would think of putting sails and spars into a boat intended for picking up a man overboard. Such a boat should be as light as practicable and should afford all possible freedom for handling the oars. The most important items to be remembered here are 1 to 11 and 19 to 23 of the list which precedes.

DETACHING APPARATUS.

Whether or not a special detaching apparatus is an improvement on the old style of links and hooks is a question upon which seamen are far from agreeing. There is substantial agreement that a "thoroughly reliable" apparatus is desirable, but a certain lack of confidence is felt in the devices now on the market.

The most important requisite for a detaching apparatus is that it should be incapable of dropping one end of the boat without the other. Whether the release should be controlled by some one in the boat or by an officer on the ship is a disputed point, but it may be noted that nearly if not quite all of the devices in current use are worked in the boat, which would seem to indicate that practical men prefer this system.

There has been much discussion as to whether the release should be capable of acting before the boat is "waterborne"; but this point, too, seems to be settled practically by the fact that, of the devices in common use, nearly all admit of dropping the boat before it touches the water.

It is very desirable to have a system which provides not only for detaching the boat, but for *lowering* the two ends together.

An effort is sometimes made to secure this result by reeving both falls in one, a single block at each davit head giving a lead from one fall to the other. With frictionless blocks this would doubtless accomplish the purpose desired, but in practice it is usually a failure unless the boat is very heavy, and fairly well balanced as to weight.

Still another point of importance is convenience in hooking on in a seaway, but this is less vital than safety in lowering and getting clear.

Several of the best known types of detaching gear are described below.

Robinson's Detaching Gear. (Plate 57.)

The hooks of this gear work between two plates which constitute a frame for the gear and which are attached to the boat by two chains as shown in Fig. 4, where one plate is removed to show the details of the gear.

The remaining plate is a duplicate of A.

H is a hook, pivoted at C and engaging a link on the lower block of the boat fall. H is prevented from turning by its bearing on the short arm of the lever L, which in turn is held by the wire lanyard F, which must be *released* to detach the boat. The tumbler K prevents accidental unhooking.

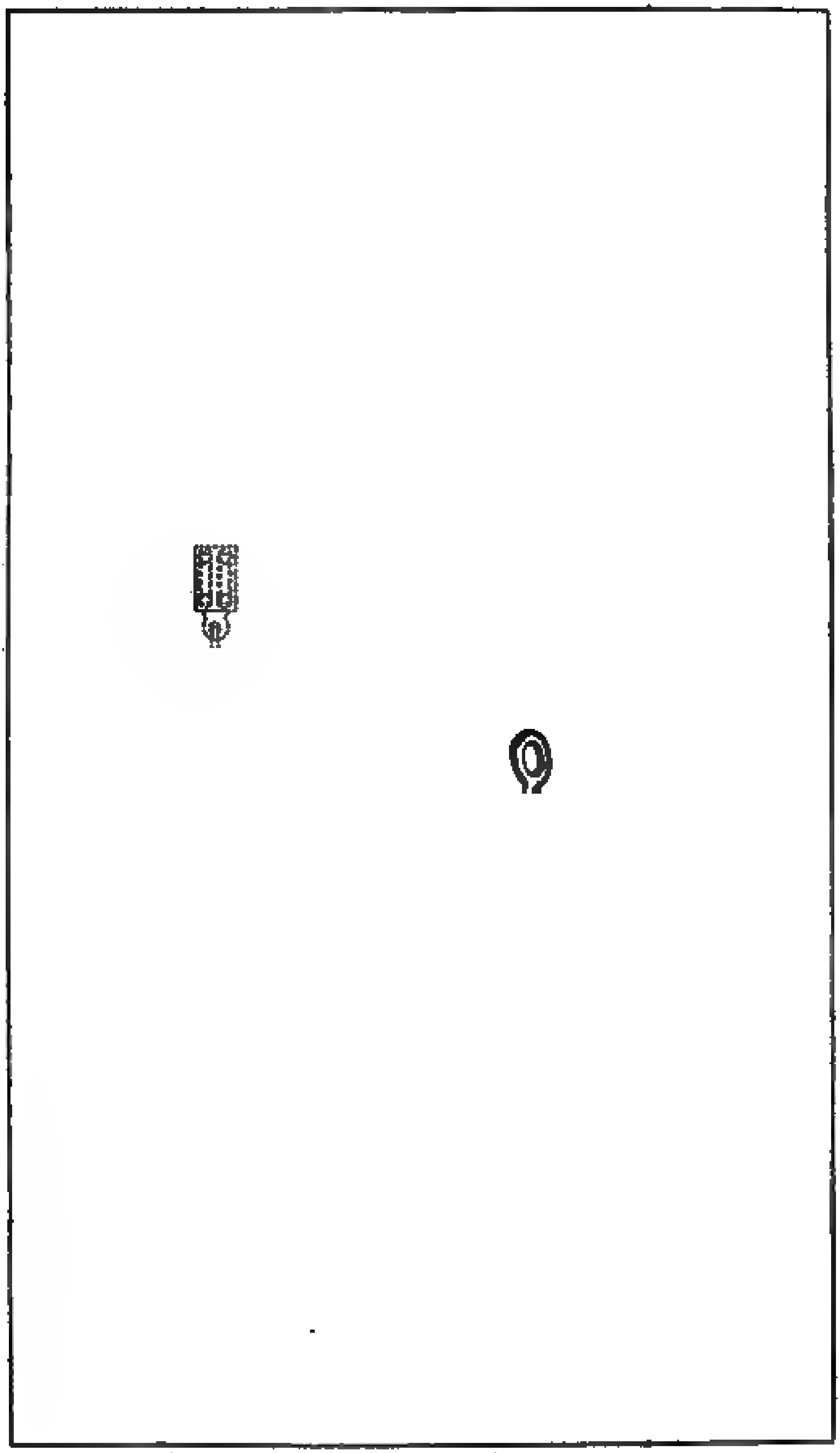
A safety-pin, G, prevents the turning of the lever if the lanyard is accidentally let go. This safety-pin should be in place at all times except when ready for lowering the boat.

To detach, the safety-pins are withdrawn and the lanyard attended. At the proper moment, the lanyard is released and the boat is freed, whether waterborne or not.

For hooking on, the safety-pins must be in place.

Wood's Detaching Gear. (Plate 61.)

The boat hangs by a link of peculiar shape, hinged at one end upon a casting firmly bolted to some rigid part of the boat. The other end of the link is held down by a chain leading over a roller and thence forward along the inner keel to a slip-hook, by means of which it is connected with the corresponding chain from the other end of the boat. A shoulder at the hinge of the link prevents it from turning down too far. Hanging from



WOOD'S DETACHING APPARATUS.

the lower block of the boat fall is a toggle with an enlarged head at the end. To hook on, the head of this toggle is inserted in the enlarged part of the link and allowed to slip up into the narrow part toward the hinge. It is prevented from slipping back, no matter how much the boat may thrash about, by a tumbler, which turns freely to let the toggle slip in, but is held, by its bearing against the link, from turning in the other direction. To detach, the slip-hook connecting the two chains and holding the links down, is released, and both links turn freely, allowing the toggles to slip through the enlarged ends of the links.

Where blocks are not supplied fitted with toggles for use with this apparatus, toggles may be made and attached to the blocks.

It is immaterial for the working of this apparatus whether the boat is waterborne or not, as the slightest pull on the falls after the chain is released will unhook them.

To use this attachment for unhooking in the ordinary way (without releasing the chain), it is only necessary to turn back the tumblers by hand, when the toggles may be slipped down to the enlarged part of the link and so freed.

Automatic Releasing Hooks.

Plate **62** shows a form of releasing hook used in the United States Navy. The hook is in two parts, hinged one upon the other with a double joint. The outer part, which forms the point of the hook, is weighted, and falls down when free to do so, disengaging itself from the link in the boat. The release can act only when the boat is waterborne, as the weight of the boat at other times holds up the other part of the hook. For hooking on, a lanyard attached to the point of the hook is rove through the link in the boat, and the hook is pulled through with this and held up in place until jammed by the weight of the boat.

To insure detaching both ends together, the falls are rove of a single length of rope "on the bight." This being the case, as soon as one hook is disengaged the slack is communicated to the other fall and the second hook released also

The following directions are from a pamphlet issued by the manufacturers of the device:

Mode of Reeving the Falls.—"If the boat is always carried outboard two single swivel blocks should be seized to the cranes about

AUTOMATIC RELEASING HOOKS.

six inches from the upper blocks at the davit heads. The falls must be in one piece, and should be passed through the two single blocks until the same amount of rope is on each side of the davits, then go to the lower and upper blocks, the same as if reeving off a set of davit falls ordinarily, with this exception—bring the hauling part of the forward fall through the forward sheave of the upper forward block, and the hauling part of the after fall through the after sheave of the after upper block. A piece of 'ratlin stuff' spliced around a bull's-eye and rove in the bight of the falls between the two single blocks, so that it will play freely between them, will enable one to secure the bight and control it if necessary, and by setting a strain on it hoist the hooks clear of the boat when they are detached. Keeping a strain on the bight and the falls, after the boat is hooked on, takes up whatever slack there is when the sea lifts the boat. By stopping the bight between the two single blocks, the falls will act independently of each other and are similar to an ordinary set of davit falls.

"If the boat is carried inboard, the single blocks should be made fast around the necks of the upper blocks with a grommet strap, so as to allow them to swing in and out with the cranes; by doing this the bight of the falls will swing clear of the upper blocks."

The Rottmer Detaching Gear.

Plate 63 illustrates this gear, which is coming into rather general use in the United States Navy, where it is viewed with much favor.

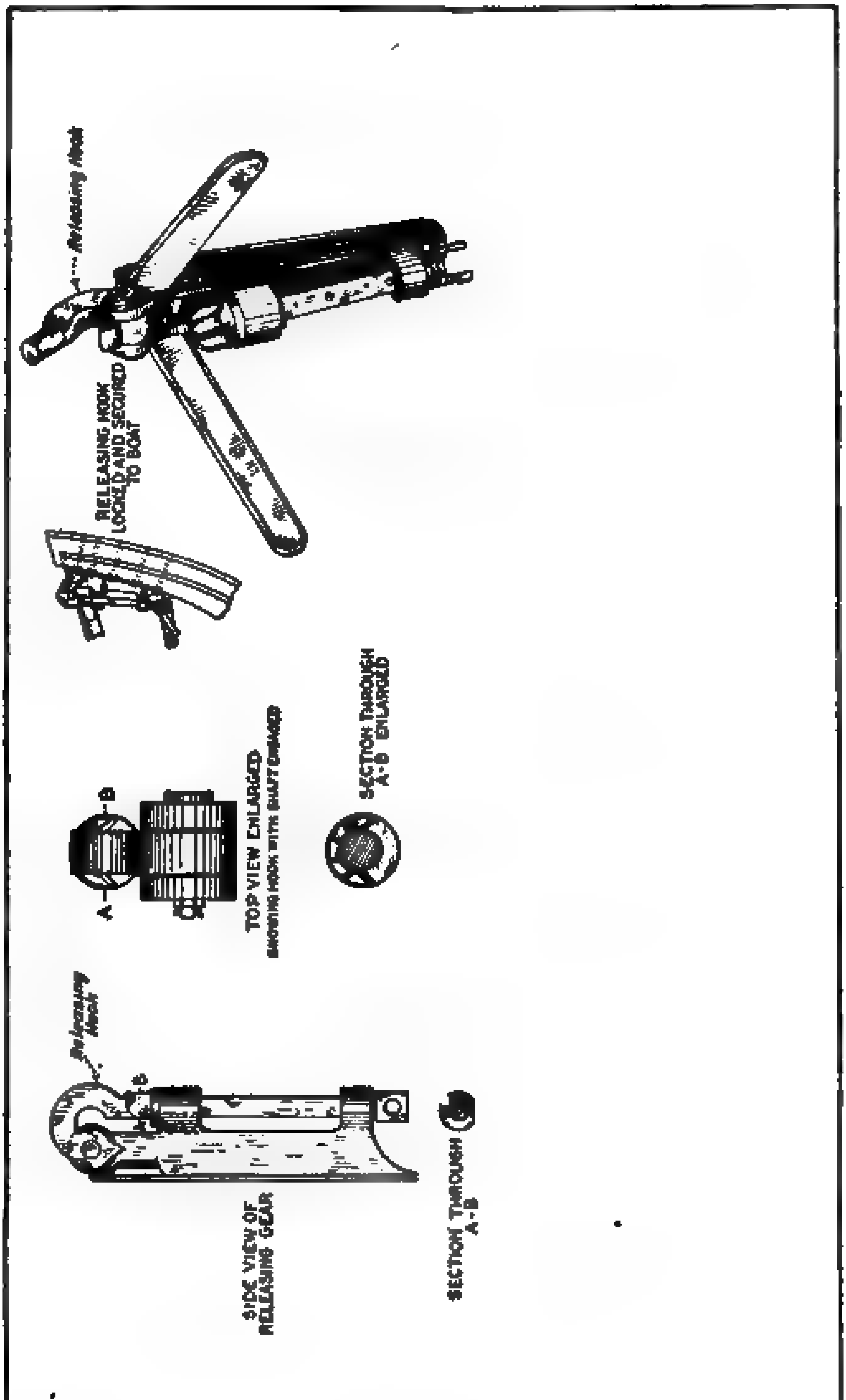
A rod, made in sections connected by knuckle joints, runs along the keel of the boat, and ends, forward and aft, in a connection, also by a knuckle joint, to an upright locking bolt which carries the detaching hook and mechanism. The upper end of this bolt is a cup, *open on one side.*

The detaching hook is pivoted; and when turned down, engages the cup on the end of the locking bolt.

If this bolt is so turned that the opening in its cupped upper end is in line with the point of the detaching hook, the hook is free to open, and the boat, if hooked on, is at once released.

If, the hook being turned down, we turn the locking bolt in such a way that the wall of the cup holds it from swinging clear, the hook is closed, and the boat may be hooked on.

Thus the key to the working of the gear lies in the position of the cupped head of the locking bolt; and this is regulated by the position of the rod, which, as already stated, runs the length of the boat and connects the mechanism at the two ends.



ROTTMER DETACHING GEAR.

The turning of the rod, and hence of the locking bolt, is determined by the position of a lever, shown in the sketch. When this lever is in the upright position, where it is secured by a pin, the locking bolt is in the locking position, the point of the detaching hook is held secure, and all is ready for hooking on.

If the lever is turned down, the locking bolt revolves, bringing the open section of the cup in line with the point of the hook, which is thus released.

For boats using the old style hook-and-link, it is well to have the link on the lower block of the fall and the hook on the span in the boat. If the hook is on the block, there is danger that it will catch under a thwart or some other part of a boat which is thrashing alongside trying to hook on in a rough sea.

Where boats are hoisted in and out by a yard-and-stay tackle or by a fall from a boom (as in the case of men-of-war boats carried inboard), a span must be used from the bow and stern, and steadying lines from the sides.

Plate 58 shows a method of fitting such a span, suitable for heavy boats.

Carrying a Quarter-boat Rigged Out.

Nearly all ships carry a quarter-boat ready for lowering in the event of a man overboard. The boat is griped in to prevent swinging, the gripes being secured by a toggle which can be slipped in an instant. The sea-painter is secured, life-lines hung from the span, the falls clear for lowering, the plug at hand, life-belts inside, the steering-oar in its crutch, water, provisions, lantern, etc in place.

To Lower a Boat at Sea in Bad Weather.

Having to lower a boat at sea, a lee boat is always selected, a lee being made, if necessary, by changing the course of the ship.

It is customary to bring the sea a little on the bow, but in this position the lee for the boat is very far from perfect. The ship will roll and pitch considerably, and waves will wash along to leeward, making things very ugly at times. Some seamen prefer to bring the sea on the quarter rather than the bow. Others advise lying in the trough of the sea notwithstanding the heavy rolling.

The best position will doubtless depend upon the build and

trim of the ship and the nature of the sea. In any case, oil should be used both ahead and astern of the boat. The ship should be kept moving slowly ahead. A sea-painter from well forward in the waist of the ship should be brought into the boat through the inboard bow rowlock and tended by the second bow oarsman with a turn around the thwart. It must not be made fast.

To keep the boat from swinging, frapping-lines may be passed around the falls, the ends leading inboard and holding the boat close in to the side as it is lowered. In some ships jackstays are fitted from the davit-heads to the side of the ship, with lanyards travelling up and down. A turn is taken with the lanyard under a thwart or around the standing part of the fall and the boat is held in, near the side, as by the frapping-line above described. Under no circumstances should the lanyard be secured to the boat otherwise than as described (by passing it under the thwart and holding on by hand). Life-lines hanging from the davit-head and from the span assist in steadying the boat and give the crew something to hold on to in case of accident. A hatchet in the boat is handy if anything jambs at a critical moment.

The great danger, both in lowering and immediately afterwards, is that the boat will be dashed against the side. The painter brought in on the inner bow as already described helps to sheer her off as she strikes the water, and the helm may be lashed hard-over toward the ship for the same purpose.

A steering-oar is better than a rudder, and where it is used the coxswain sheers the bow out by throwing the stern in as the boat strikes the water.

The after fall is always unhooked first.

Under no circumstances short of the most imperative necessity should a boat be lowered while the ship has sternway, and it is always desirable to have a little headway. There is much difference of opinion as to the speed at which it is sale to lower a boat, an important question in picking up a man overboard. Many officers, having seen boats lowered without accident at speeds as high as eight and ten knots, maintain that it is perfectly safe to lower at this speed. A more conservative view fixes the maximum at something like half this speed. It is safe to say that there is far less danger at five knots than ten, and most practical

men would prefer to wait a little longer rather than to take the chance of having to deal with a whole boat's crew in the water.

Lowering a Stern Boat.

Here, as soon as the boat touches the water, the after fall is let go altogether and the boat allowed to swing at once parallel to the course of the ship, towing by the forward fall, which is then unhooked or, in an emergency, allowed to unreeve.

Hoisting.

To hook on and hoist a boat in a seaway is quite as difficult as to lower and detach it. The ship is handled in such a way as to make a good lee, and it is well that she should be moving very slowly through the water, but the screws should be stopped while working with the boat. The falls are overhauled ready for hooking on, but it is a good plan to have a hand at each davit-head holding the blocks clear as the boat comes alongside to avoid danger of hitting the men in the boat. The falls are well manned, with force enough to *run away* when ordered to do so. If a winch is to be used, the proper turns are taken loosely around the drum and the winch is started. The sea-painter, from well forward, is led aft and held in a coil by a good man who stands by to throw it to the bow oarsman in the boat at just the right instant. It is convenient to have a light line bent to the painter near the end for hauling it in for another throw in case of missing the boat.

The officer who is to direct the maneuvre should take his place on the rail as close as possible to the point where the boat is to be hoisted.

The boat pulls near the ship abreast of her falls or a little astern of them, and waits to receive the line, the bow oarsman laying in his oar and standing by. The line is thrown and caught, and a turn is taken around the forward thwart. The oars are then laid in as quickly as possible and the boat is dropped in alongside the ship and under her falls by careful use of the steering oar; being hauled ahead *slowly*, if necessary, by the sea-painter, which is manned on board the ship by a few men only. If the coxswain is skilful, he will work her slowly in, first canting her head slightly toward the ship and then catching her before

she can touch, by throwing her stern in enough to straighten her up parallel to the ship.

Two men stand by to breast her off with boat-hooks if necessary.

If the ship is making way through the water, a line should be used from the stern of the boat, leading well aft on the ship, to hold the boat from launching forward as she leaves the water.

The men who are to hook on forward and aft see the links in the boat ready and stand by with the lower blocks. Oil should be used to calm the sea if necessary. When all is ready in the boat and on deck, watch for a smooth time and as the ship starts to roll toward the boat, hook on forward, then aft; then, "**Set taut!**" "**Hoist away!**"

Man-of-War Rules with Regard to Life-Boats.

At Sea. When at sea, every ship shall at all times keep on each side, ready for lowering, a boat which is best adapted for a life-boat.

At the beginning of every watch at sea, the officer-of-the-deck shall have the life-boat crew of the watch mustered abreast the lee boat, and the coxswain of the life-boat crew of that watch shall satisfy himself by personal inspection that *both* life-boats are ready for lowering, and shall report the fact to the officer-of-the-deck.

A life-boat is secured for sea, *i. e.*, ready for lowering, when in the following condition: Boat at the davits, griped in, falls clear, detaching apparatus ready for detaching at the word, steering-oar shipped in crutch, oars fitted with trailing lines and ready for getting out quickly, rowlocks shipped and fitted with lanyards, plug in, sea-painter half-hitched around forward thwart, life-lines bent to span, life-belts in boat, lantern filled and trimmed (and at night, lighted), and all other articles of the boat-equipment in the boat and ready for use, with two days' water and provisions for the crew. When the coxswain of the life-boat crew of the watch reports a life-boat ready for lowering, it is understood that the boat is in the above condition and that the crew of the watch have been mustered, each man abreast his own thwart (or station) of the lee boat, and that each man understands his duties at "Man-overboard." In lowering, the officer or coxswain in charge of the life-boat will give the command for detaching.

In Port. The U. S. Navy Regulations require that "In port, one or both life-boats shall be kept ready for immediate use from sunset until colors the next morning;" hence when there is no suitable boat in the water ready for immediate use as a life-boat, at least one boat suitable for this purpose must be kept ready for instant lowering. This is particularly necessary when the boats which are in the water are heavy and unwieldy, or are so secured that they could not be quickly used in

an emergency, or in rough weather, or in a strong tideway. The officer-of-the-deck shall require the coxswain of each life-boat to report to him, each day at sunset, the condition of his boat as regards readiness for service. If the regularly designated life-boats for port service are reported as not being available for use, he will at once take steps to provide another boat for this duty.

In port, the regular crews of the designated life-boats will act as life-boat crews from "turn to" in the morning watch until 9 p. m.; from 9 p. m. until turn-to in the morning watch, the anchor-watch will be the life-boat crew, and when mustered the men shall be assigned their stations. The petty-officer of the anchor-watch will report that the crew have been stationed and that the life-boat is ready for use.

Owing to its handiness, a dinghy is well suited for use as a life-boat in port in good weather, and under such conditions it may be designated as the life-boat for port service. The boats designated for use as life-boats in port are required to carry only the usual equipment for boats in port, but the gear must be in order and ready for instant use, and the lantern must be ready in the boat for lighting, or else a lighted lantern ready for use must be kept at hand on deck.

Life-boats should be griped securely against their strongbacks, with chafing-pads between the boat and the strongbacks; and the gripes, secured either by toggle or pelican hook, ready for instant freeing.

If gripes stretch and become slack, they should be set up taut.

At night, boat-falls should be coiled down on deck, clear for running; during the day the coils may be triced up to davit with becket and toggle.

The sea-painter is led from a point well forward on the ship, outside of everything, and secured to the inboard side of the forward thwart in such a manner that it can be readily cast off; if necessary, it is stopped up out of the water by a rope-yarn.

The knotted life-lines, one for each member of the crew, hang from the span for the use of the crew in case of accident in lowering or hoisting.

An axe or hatchet should be kept at hand, ready for instant use in case of a jam while lowering.

The life-belts should be placed, one under each thwart, and one under the stern-sheets, and each man in the life-boat will put on a belt before the boat is lowered. This is necessary because of the danger of the boat swamping alongside in rough weather.

If the lantern is not provided with a shutter, it will be fitted with a canvas screen, and when lighted and not in use will be put in the boat-bucket.

Life-boat crews for each watch are designated on the ship's station-bill. When a life-boat crew is mustered, the men will muster in line abreast their boat (or the lee boat), in the order of their thwarts, facing inboard; men stationed to lower will be abreast their respective davits, and will personally see that the falls are clear.

The proper members of the crew will be permanently stationed for unhooking the falls, tending the sea-painter and for performing other duties in connection with lowering. The life-boat crew of the watch, including the men stationed for lowering, for observing the man, for signalling, etc., are not to go below the upper deck without permission, except for meals.

At night the life-boat crew of the watch, and other men stationed in connection therewith, will remain near their stations.

At the call "Man-overboard" (which may be given by word of mouth or sounded on the bugle), every member of the life-boat crew of the watch goes to his station on the *run*. The lee life-boat should be manned. If there is any doubt about which boat is to be lowered, the officer of the deck immediately indicates it by the command, "Clear away the starboard (or port) life-boat."

The men take their seats on the thwarts; each man immediately puts on a life-belt, gets his oar ready, and then, if not otherwise engaged, seizes a life-line as a safety precaution in case of accident.

When all is ready, the officer-of-the-deck, or the officer in charge of the lowering, commands LOWER AWAY TOGETHER! The bow and stroke oars tend the falls to keep them clear and to keep the blocks from striking other members of the crew when let go. In case the tumbler-hook is used, these men grasp the tumbler-lanyard, and as soon as the boat is water-borne, unhook the fall, in case it is not unhooked automatically. Should the boat not be supplied with detaching apparatus, these men unhook the boat-falls—*the after fall first*—as soon as possible after the boat touches the water. Men in the waist thwarts hold the boat off, if the ship is rolling. The second bowman tends the sea-painter, which is hauled taut and brought in through the inboard bow rowlock before lowering. He takes a turn with the painter around the thwart, holding the end in his hand. It should never be made fast.

In lowering a boat the falls must invariably be lowered together, and in rough weather smart lowering may be required.

If the boat is held in by lizards traveling on jackstays, or by frapping-lines around the falls, some of the men in the waist should breast the boat off the ship's side with the boat-hooks.

Have an axe or hatchet handy in case anything should jam at a critical time.

When the boat is a short distance from the water, the officer of the boat, or in his absence the coxswain, lets go the detaching apparatus, or gives the command LET GO! If the boat is not fitted with detaching apparatus, as soon as boat is water-borne, the boat-officer or coxswain commands LET GO THE AFTER FALL!, then, LET GO THE FORWARD FALL! The coxswain gives the boat a sheer out, by throwing the stern in. As soon as the boat is clear of the side, the painter is cast off, the oars are gotten out, and the boat proceeds in search of the man overboard.

§III. RIG OF SHIPS' BOATS FOR SAILING.

It is not to be expected that a boat built for a great variety of purposes, of which sailing is by no means the most important, should sail as if designed for that purpose alone. Not only must the lines and dimensions of the boat be regulated by the demands of general utility, but even the rig for sailing must be fixed by quite other considerations than those of speed and weatherliness. The spars and sails must be light and easily handled, and must stow compactly when the boat is under oars. They must admit of carrying passengers and stores, of coming alongside safely, of hooking on and hoisting conveniently. The fewer, shorter, and lighter the spars, the better. Masts, especially, should be short and light, easily stepped by a few men, and calling for little support from shrouds and stays. Bowsprits and booms are particularly inconvenient, as are also the bumpkins which in some rigs project beyond the stern. A rig which entails danger of capsizing if it chances to be caught aback is of course objectionable.

Of the rigs considered suitable for man-of-war boats, the most common are the following:

1. **A gaff and boom mainsail** with bowsprit and jib. Used in the United States Navy for launches (Plate **64**, Fig. 1).

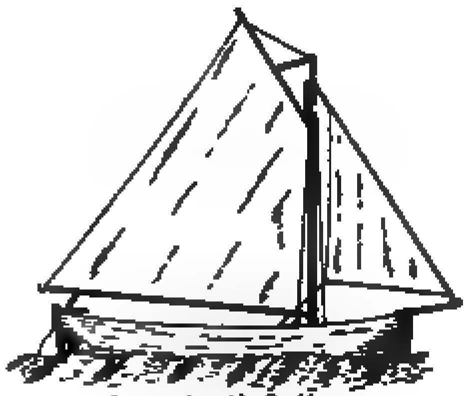
2. **A gaff mainsail without a boom** and a jib without a bowsprit. Used in the English Navy for launches, and called, from the admiral who introduced it, the "De Horsey" rig (Plate **64**, Fig. 2). A topmast is sometimes added to this rig, making it possible to carry a gaff-topsail and another jib.

The arrangement devised by Admiral de Horsey for handling the mast of this rig is of such convenience that it might well be adopted for all boats having rather heavy masts to be stepped and unstepped. The mast is mounted on trunnions at the height of the thwarts and as it is lifted, turning about these trunnions, the heel is guided into the step by a light frame shaped to the arc about which the heel moves.

3. **The dipping-lug.** Used in the English Navy for pinnaces and cutters, usually in combination with a standing-lug main or mizzen (Plate **64**, Fig. 4).

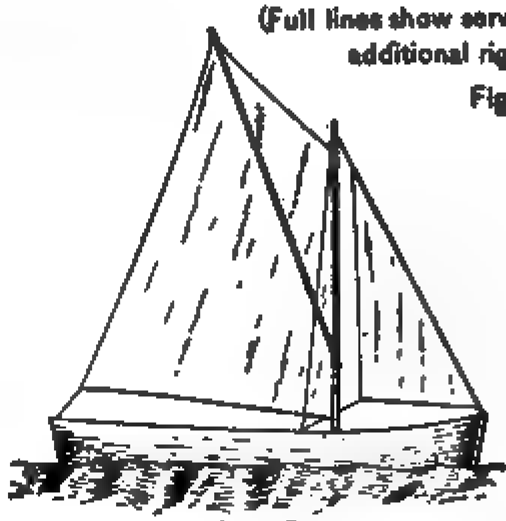
4. **The standing-lug.** Used in the United States Navy for cutters, and in the English Navy for the main and mizzen of cutters and whale-boats. (Plate **65**, Fig. 4).

5. **The balance or French lug.** Used in the French Navy for cutters (Plate **65**, Fig. 3).



Launch – U. S. Navy.
(Gaff and Boom Rig).
Fig. 1

(Full lines show service rig; dotted lines additional rig for racing).
Fig. 2



Sprit Rig.
Fig. 3

Standing Lug Mizzen,
Fig. 5

Fig. 4

RIG OF BOATS FOR SAILING.

6. **The sliding-gunter.** Formerly used in the United States Navy for cutters, whale-boats and gigs (Plate **65**, Fig. 1).

7. **The sprit.** Used very generally for dinghys and other small boats (Plate **64**, Fig. 3).

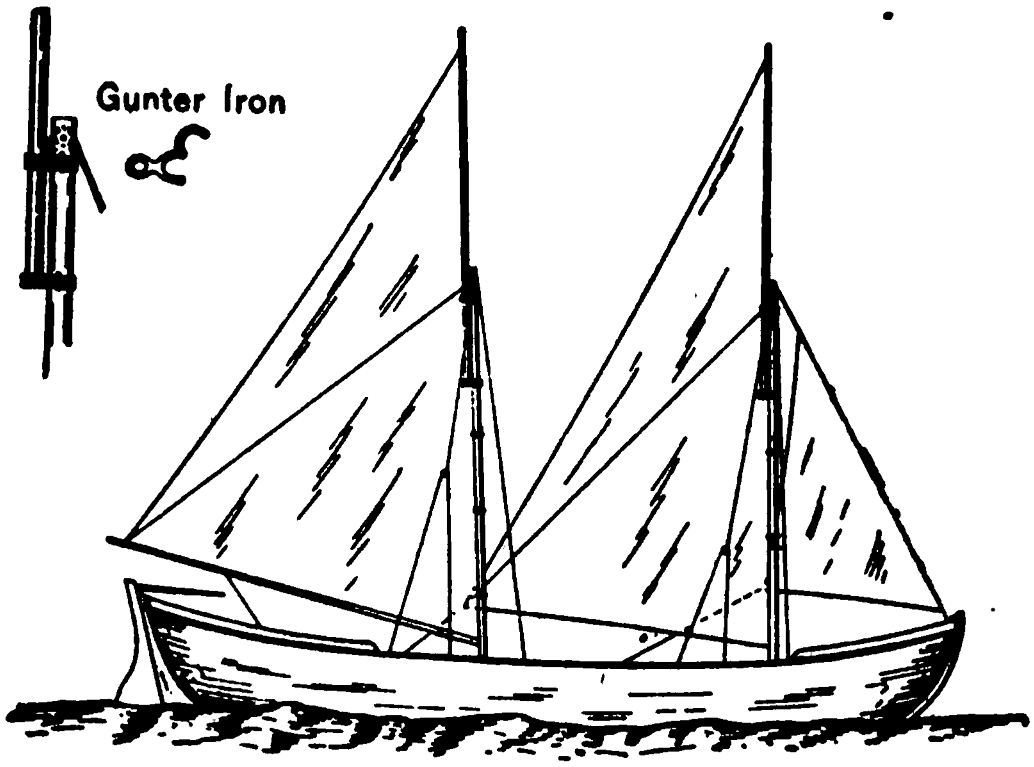
Of these rigs, the dipping-lug is commonly regarded as the best for speed and weatherliness, but it is hard to handle and even dangerous with any other than a very smart and well-drilled crew.

The standing-lug is safe and convenient to handle, but lacks something of the driving power of the dipping-lug.

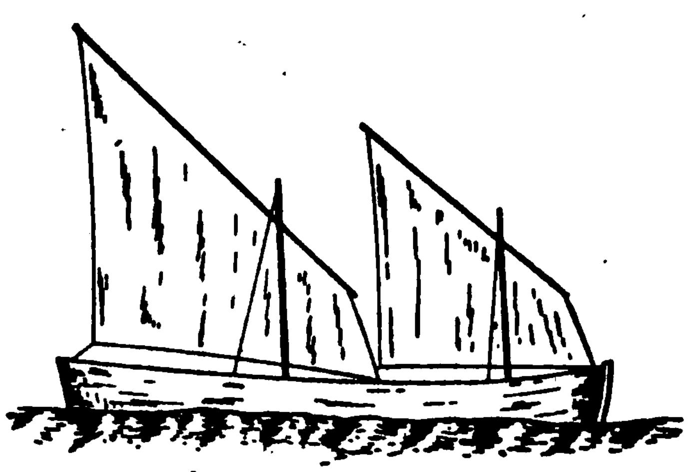
The French lug is a compromise between the two preceding rigs and combines many of their advantages. It may, in fact, be used either as a standing- or as a dipping-lug, the forward yardarm being dipped if either. If it is not dipped, the yard lies to windward of the mast on one tack and to leeward on the other. This rig perhaps combines as many points of excellence as any that could be named.

The details of rigging for lug sails vary considerably, but the yard is always attached to the mast by a traveller moving freely up and down. The halyards are usually rove through a sheave in the mast, but sometimes through a block at the mast-head. A down-haul should always be fitted and it is convenient to use for this the bending end of the halyards. As a rule, no shrouds are used, but the halyards are set up to windward and abaft, and serve to support the mast, except in cases where the forward yard-arm dips; in which cases the halyards lead down forward of the mast amidships. The most convenient way to fit the halyards is to use a pendant with a single block at the end, through which a fall is rove.

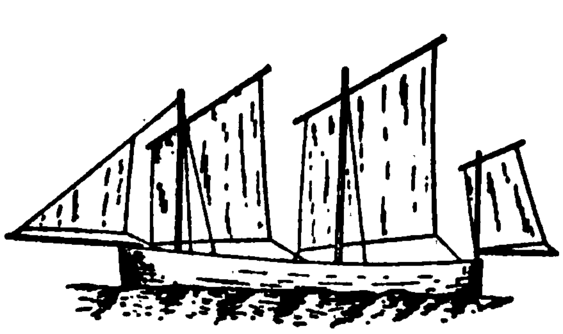
In the English Navy the larger cutters carry a dipping-lug foresail and a standing-lug mainsail, the latter being replaced in cutters of twenty-seven feet and under, by a mizzen stepped at the extreme stern of the boat with a bumpkin rigged out beyond the stern for the sheet. As the mizzen is of necessity a small sail, the foresail must be large, to give a fair spread of canvas, and being a dipping-lug it is not convenient to handle. In spite of this and the seeming clumsiness of the mizzen, with its boom and bumpkin projecting from the stern, this rig is much liked in the English service. It involves very little gear, and is quickly and easily rigged. The greater part of the sail area, being in a



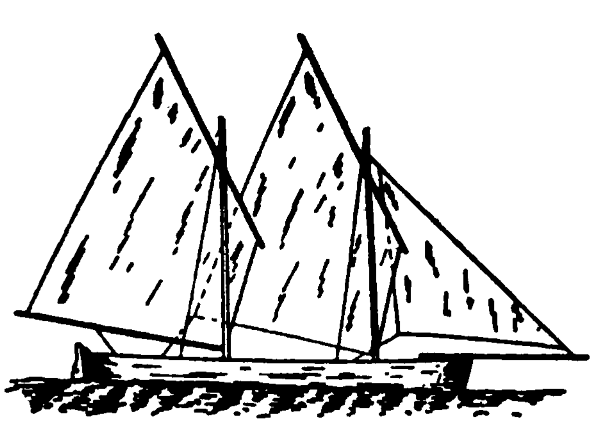
Sliding Gunter
Fig. 1



Low Dipping Lugs
Fig. 2



Balance (French) Lug
Fig. 3



Standing Lug
Fig. 4

RIG OF BOATS FOR SAILING

single sail reaching well out to windward and with nothing forward to becalm it, is favorably placed for holding a wind; and boats with this rig sail faster on a wind than those with their canvas divided between a fore and main; but they are at a disadvantage in reaching, and they do not lie-to well. The forward part of the foresail acts as a jib, but with greater pull and smaller leverage; and the absence of a bowsprit is an advantage in going alongside and in plunging into a head sea.

The halyards of a dipping-lug are bent one-third of the length of the yardarm from the forward end. The tack is usually hooked to the stem, except in sailing free, when it is shifted to the weather bow. Some seamen prefer to hook it always to the bow, but the boat will not point quite so high with it there. The most serious danger connected with the lug arises from the fact that if the sail gets aback, it binds against the mast and cannot be lowered. In this situation, in a fresh breeze, there is serious danger of capsizing. It is a good plan to make the tack fast with a "slip-hitch," which admits of casting it off in an instant, when the sail immediately spills, as it is a characteristic of the lug that its stability depends entirely upon the tack.

The dipping-lug sometimes takes the shape of Fig. 2, Plate 65, which, it will be seen, is an approach to the latteen rig. Here the forward yardarm is the one to be dipped, and the luff is short enough to admit of dipping without lowering the yard. The tack makes fast amidships, a light jigger being used to get it well down. The halyards are led down forward, close in to the mast, and, as in all cases where the halyards are not available for supporting the mast, the mast must be stout and well secured at the partners. Like the French rig already described, this rig, although designed for dipping, will work fairly well as a standing-lug. It is well suited for boats like gigs (old style) which are not built for sailing and have not the stiffness to stand up under a rig whose center of effort is high.

The tack of a standing-lug is made fast to the mast, and the halyards are bent one-fourth of the length of the yardarm from the end. With the balance-lug, the tack may conveniently be fitted to travel across on an iron rod or "horse" just forward of the mast. The point for bending the halyards varies.

The sliding-gunter is one of the safest and most convenient of rigs for boats of small and medium size, but it has comparatively little driving power, particularly on a wind, and for all-around

work is distinctly inferior to several of the rigs that have been mentioned above. Sail is reduced in an instant by letting go the halyards, and taken in altogether by tricing up the boom (or clew) as the topmast comes down, brailing up at the same time. This is done as easily with the sails aback as when they are full. On the other hand, the spars are awkward to handle, and still more awkward to stow, since the lower mast, topmast, and sails are usually made up together. This makes it inconvenient to carry the rig in the boat when under oars and impossible to do so if the oars are to be used in rough water. It is a great improvement to make the gunter-irons with clamps so that the top-mast and sail can be stowed separately from the lower mast. A good deal of power is required to step the masts in shifting from oars to sail, particularly if the boat is rolling.

The halyards of the sliding gunter are bent to the neck of the upper gunter-iron and lead through a sheave in the mast. The clewrope leads from the clew to the proper point on the mast for tricing up the boom snugly.

§ IV. HANDLING BOATS UNDER SAIL.

TRIM.—To do her best under sail, a boat must be trimmed in accordance with her build and rig.

If she carries considerable head sail, she will need to be deeper forward than would otherwise be desirable. If she has little or no head sail, she should trim by the stern. The build and rig are fixed upon with reference to each other, due consideration being given to the purpose for which the boat is designed. Once fixed, these characteristics are practically permanent. The *trim* of both boat and sails, on the other hand, can be varied within rather wide limits; but they, too, must be considered with reference to each other. Most boats when on the wind sail best when carrying a little weather helm; that is to say, when they have a slight tendency to come into the wind. Too much weather helm may be corrected by shifting weights aft; too much lee helm, by shifting forward.

The weights should be kept out of the ends of the boat, with-

out being unduly crowded together amidships. It is especially important to keep heavy weights out of the bow. The only ballast, *as such*, that should be carried, is water in breakers. Under no circumstances should "sinking" ballast be allowed; ballast, in other words, which is heavier than water. The lower the weights can be stowed, the better; but care should be taken to keep the *well* clear for baling. Ballast and cargo must be secured against the possibility of shifting. The crew should be kept well down and nobody allowed to stand on the thwarts or to sit on the gunwale. If the men are sitting to windward in a fresh breeze, they should move amidships for passing under the lee of a vessel or other object, where the wind may fail or even shift in an eddy. The mast should be properly stayed, up and down or with a slight rake aft, and the halyards taut up.

In a lug rig, the halyards act as a weather shroud, the tie being led down to windward and abaft, and set up by a purchase. In most other rigs, shrouds are fitted.

On the wind, as has been said, a boat should carry a little weather helm.[1] The sails should be kept well full, sheets not too flat, but everything drawing and the boat *alive*. It is a common mistake to get the sheets so flat that the boat, while pointing high, actually makes a course to leeward of that which she would make if kept away a little with sheets eased accordingly; and it is of course clear that if kept away, her speed will be greater than when jammed up into the wind in the hope of stealing a fraction of a point. A boat of good draft with a deep keel or centerboard, and yachts designed for racing, with fin-keels hanging ten feet below their normal draft, will lie amazingly close to the wind with little or no leeway. Ship's boats, however, are not constructed on yachting lines and cannot be held up in the same way.

Sheets may be hauled flatter in smooth water than in rough, and the sheets of standing lugs, gaff- and boom-sails, sliding-gunters and the like, may be hauled flatter than those of dipping-lugs. The sails being properly set, the weather cloths of the sails are kept just trembling, with weather helm[1] enough to let the helmsman "feel" that she wants to come into the wind. As the wind will vary more or less (in apparent, if not real, direction), it is necessary to be watchful and to bring her up or keep her away from time to time in order that she may be always at her

1. lee rudder.

best. The sails should be kept fuller in rough than smooth water, and it is more important that the boat should be kept *going* so as to be always under command of the helm.[3] If a heavy breaking sea is seen bearing down upon her, she should be luffed to meet it and kept away again as soon as it has passed. If she loses way she becomes helpless at once. It is dangerous to be caught by a heavy sea on the beam; and if the course to be made in rough water would bring the boat into the trough of it, the best plan is to run off for a time with the sea on the quarter, then bring her up with it on the bow, and so to make good the course desired without actually steering it at any time.

It is a universal rule in boat sailing that the sheets should never be belayed in any weather.

For a moderate squall, the boat should be luffed sufficiently to shake, without spilling, the sail, thus keeping headway enough to retain control, but with the sheet (as always) in hand. If it comes stronger, she must be luffed more decidedly and the sheet slacked more or less. The sheet may of course be let go, and in a sudden emergency this must be done at once in addition to putting down the helm,[3] and, if necessary, reducing sail; but the longer she can be kept under control the better, and to let go the sheet is to give up control.

The situation is quite different in running free. Here the sail cannot be spilled by a touch of the helm,[2] and the only prudent thing is to slack the sheet while luffing. The force of the wind would be much reduced by running off, but the trouble with this is that if it comes too strong there is no resource but to lower the sail, and the chances are that it will bind against the shrouds and refuse to come down. Moreover, there is always danger that the wind will shift in the squall, and the mainsail may gybe with dangerous force.

REEFING.

When a boat begins to take in water it is time to reef. And she should never, even in smooth water, be allowed to heel too much. A boat that is decked over may run with her lee rail awash; but when an open boat is approaching this point it must be remembered that a fresher puff may bear the gunwale lower without warning, and that the moment it dips, the boat will almost certainly fill and capsize. The details of reefing will depend upon the rig, but a few general rules may be laid down. The men

2. rudder. 3. tiller.

should be stationed before beginning, and should all be required to remain seated. One hand lowers the halyards as much as may be necessary, another hauls down on the luff and shifts the tack. The sheet is hauled in a little to let the men detailed for the reef points get hold of and gather in the foot. The sheet is then slacked and shifted, the points passed, the halyards manned, the sail hoisted and the sheet trimmed. It is important to keep the boat under command while reefing, and for this she must have way enough to obey her helm.[1] If she can be luffed a little and still kept going through the water sufficiently to obey her helm,[1] then it is unquestionably wise to luff, but not sufficiently to risk losing control by the helm.[1]

If the boat has more than one sail, it is a good plan to reef them one at a time.

RUNNING BEFORE THE WIND.

This is the most dangerous point of sailing in a fresh breeze because of the chance of gybing. The danger increases if the boat yaws, as she will have a tendency to do if trimmed at all by the head; from which follows the rule, in running, to keep the weights fairly well aft, though never at the extreme after end. Very careful steering is required; and if the sea is really heavy, the chances are that the boom will gybe in spite of all the care that can be taken, unless lashed to the rail or a shroud by a "lazy guy."

Squalls are not so dangerous before the wind as when close-hauled, unless they are accompanied by a shift of wind.

If they call for any reduction of sail, it may be made by dropping the peak of the mainsail (if a gaff sail) or, more satisfactorily, by reefing.

The foresail is sometimes set on the side opposite the mainsail, in running before the wind, a temporary boom being rigged by using a boat-hook or an oar. A boat sailing in this way is going "wing and wing."

If the sea is rough, it is well to avoid running with the wind dead aft. To make a course directly to leeward, the wind may be brought first on one quarter and then on the other, the mainsail being clewed up or the peak dropped each time the course is changed, if the breeze is strong enough to make gybing dangerous.

1. rudder.

A serious danger in running before a heavy sea is that of "broaching-to." The boat will yaw considerably, the rudder will be often out of water when it is most needed to meet her, and the sails will be becalmed in the trough of the seas. The situation here is much like that of a boat running in a surf; and, as in that case, the yawing will be reduced by keeping the weights aft and by steering with an oar. The jib should always be set, with the sheet flat aft. It helps to meet and pay her off if she flies to against the helm. A drag towed over the stern is also helpful.

Another danger in running is that the boom may dip as she rolls and thus capsize the boat.

TACKING.

In tacking, the same principles apply to a boat as to a ship. After-sail tends to bring her head to wind, head-sail to keep her off; but all sails, so long as they draw, give her headway and so add to the steering power of the helm.[1]

It is clear that a short full boat will turn to windward better than a long and narrow one and will require a much shorter distance for coming round. Thus a short boat is preferable to a long one for working up a narrow channel.

Under ideal conditions, a boat close-hauled but with good way on, shoots up into the wind as the helm[2] is eased down, making a good reach to windward and filling away on the new tack without for a moment losing headway. The main boom is hauled amidships, and, as the jib and foresail lift, their sheets are let go. The boat comes head to wind and as she pays off on the new tack the sheets are hauled aft and she is steadied on her course. Under less favorable conditions, tacking is not so simple. If there is a sea on the bow advantage must be taken of a smooth time to ease the helm[2] down; the main boom must be hauled amidships gradually, and the foresail kept full as long as it will draw. If the boat loses headway, the jib sheet is held out on the old lee bow (not too far) to pay her head around, and care must be taken not to make a "back-sail" of the mainsail. As she gathers sternway, the helm[1] is shifted, and, if necessary, an oar is gotten out to help her around. Carrying the weights forward is favorable for tacking, but when a boat has sternboard she may be helped around by putting a few of the crew on the (new) lee quarter, where, by increasing the immersion of the full lines of the

1. rudder. 2. tiller.

counter, they add to the resistance and cause the bow to fall off.
counter, they add to the resistance and cause the bow to fall off.

If she gets "in irons," either an oar must be used or the jib and fore sheets must be hauled over on the old tack, flat aback, to give her stern board. This last is a dangerous maneuver in a strong breeze and rough sea.

The statement is sometimes made that it is *lubberly* to use an oar in a boat under sail. The lubberly part is the getting into a position where an oar is needed. Being in such a position, it is proper to use the oar for getting out.

Attention may again be called to the fact, already mentioned more than once, that in squally weather, a boat is in a dangerous position whenever she is without headway, because she can neither be luffed nor kept away in the event of being struck by a heavy puff. If, through ignorance or carelessness, the sheets are belayed at such a time, the danger is enormously increased.

On July 17, 1902, a sail-boat full of people, in charge of an experienced fisherman, was capsized near the Isles of Shoals, off the coast of New Hampshire, under the following circumstances:

The weather had been stormy, but had moderated. The wind was light but puffy, and there was a rather heavy sea running. The boat had tacked, but had not gathered headway and was lying in the trough of the sea when a squall struck her. The sheets were belayed. The helm was put down, but the boat, having no way, could not answer it. A sudden dash of spray caused the passengers to crowd hastily to leeward, and this, added to the effect of the squall and the sea, capsized the boat. Fourteen lives were lost.

Some years ago a schooner yacht was lying at anchor in New York harbor, with foresail and mainsail set and the sheets belayed to prevent the sails from slatting about. A sudden squall came up, on the beam, and the yacht capsized before she had time to swing.

WEARING.

In wearing, the helm[2] is put up and the main sheet slacked away roundly The boat goes off before the wind, the mainsail is either gybed, or clewed up and shifted over (preferably the latter) and the boat is hauled up on the new tack, losing more or less ground to leeward according to circumstances. The details of the maneuver may vary, considerably according to the conditions of wind and sea and the peculiarities of the boat as to rig and trim. In a light breeze, the main sheet is slacked away roundly until the wind is aft, then hauled in smartly for

2. tiller.

gybing and eased away steadily on the new lee quarter. In a fresh breeze, as gybing would be dangerous, the mainsail is clewed up just before the wind comes aft, and set again in time to bring her to the wind on the new tack; or, in the case of a "cat" or other rig where the head of the mainsail sets on a gaff, the peak is dropped to reduce sail temporarily.

The fore and jib sheets are shifted when nearly before the wind. As she comes to on the new tack, they are left flowing until hauled aft to meet her by the wind.

REMARKS ON GYBING.

A sail is "gybed" when it is allowed to swing from one side to the other, the wind being aft or nearly so, and the sail full first on one side and then on the other. This may be done intentionally, as in wearing or in changing course, or it may come unexpectedly from a shift of wind or from the yawing of the boat. As it necessarily involves a violent swing of the sail, it puts a heavy strain upon the spars and fittings and causes the boat to lurch more or less deeply to leeward. Moreover, the violent sweep of the boom across the stern endangers everybody in its path.

In a light breeze, these dangers are perhaps not serious enough to justify the rule that a mainsail should never be gybed, but in a fresh breeze it should not be thought of; and the fact that it is often done by experienced boatmen does not make it any more seamanlike.

When a necessary change of course in a fresh breeze will bring a shift of wind from one quarter to the other, the sail should be lowered or clewed up for a moment before putting up the helm,[1] and then set again on the other quarter. If this cannot be done and it is still necessary to gybe, *the peak should be dropped,* the boom hauled in slowly and eased away on the new tack.

With a sliding-gunter rig the mainsail should be brailed up for gybing.

1. tiller.

§ V. HANDLING A BOAT UNDER OARS.

There is perhaps quite as much art in handling a boat under oars as in handling it under sail, but comparatively little of this art can be taught by precept. There is of late years a tendency in all navies to rely very much upon steamers and motor boats, and as a consequence of this it has become rare to see man-of-war boats handled with the smartness which characterized the best of them not many years ago. Yet the need of just such training as produced this smartness is greater now than ever before, because of the changes which are making of the modern man-of-war's man a mechanic and a soldier rather than a sailor.

In going into a crowded or difficult landing, pull easily and keep the boat under control with the oars as long as possible.

In going through a narrow entrance, get good way on the boat, then trail or toss the oars.

Remember that a loaded boat holds her way much longer than a light one.

In pulling across a current, try to get a *range* of two objects in line and steer by these to avoid being set down by the current.

Having a long pull against the tide, run inshore where the tide is slacker than in midstream.

If the weather is thick or may become so, make sure you have a compass in the boat, and note the course you must make coming and going.

There should always be a lantern, filled and trimmed, in the boat, and boats should never leave the ship for a trip of any great length without a compass. Weather is liable to thicken at any time, and a boat without a compass would have difficulty in reaching a landing or returning to the ship. For this reason, boat-officers and coxswains of running-boats should at all times know the compass course between the ship and landing, and if they are away from the ship and it begins to thicken, they should at once observe the compass course before the ship is shut in, and note the direction and force of wind and current.

If taken in tow by a vessel, make her give you a line instead of taking your painter, and keep this clear for letting go in an instant. If towing astern, hold on with a short line close up under the counter; if towing alongside, have a long line and watch your steering.

Never go alongside a vessel when she has stern way. In a seaway always board a vessel to leeward, unless there is wreckage floating alongside.

(See Chapter "Rescuing the Crew of a Wreck.")

In coming alongside in a seaway or a strong tide, warn the bow oarsmen to look out for the line which will be thrown from the ship.

Caught in a Gale in a Boat.

Rig a sea-anchor by lashing the spars and sails together, the sails loosed. Fit a span to this and ride by the painter. If there is oil in the boat, use a bag of it on the sea-anchor.

Running a Line.

Coil the greater part of the line in the stern sheets, but take end enough in the bow to make fast when you reach the landing. Pull away and let the ship pay out more line until you are sure of having enough in the boat to reach, then pay out from the boat. Always have plenty of good seizing stuff for making all secure, and if you are to stand by the line, have an axe for cutting if ordered.

If laying out with the tide, take less line in the boat than otherwise; if against the tide it will save work to take all the line in the boat, pull up and make fast, then bring the end back to the ship. With a long line to be laid out in a strong current, it will usually be necessary to have several boats, one to run away with the end, the others to underrun at intervals, floating the line and pulling up stream with the bight.

If the line is to be secured to a post, put a bowline in the end before starting, and throw this over the post. Bend on a heaving line and let the bow oarsman throw this if hands are standing by to take it, or jump ashore with it himself if necessary.

Towing.

In ordinary cases of towing—*an unladen boat* in a *smooth sea*—the towing boat passes clear of the oars of the tow (oars of tow should preferably be tossed to facilitate this), placing herself in line ahead, receives painter from the tow, secures it to ring-bolt in stern-post, and starts ahead immediately she has hold of the painter.

The bowman in the tow must not give the towing boat his painter until she is in line ahead; he will then take in the slack of the towline, keeping a strain on it, and gradually pay it out, thus getting way on the tow gradually. This latter precaution is particularly necessary if the tow is at all heavy.

Though it is frequently impracticable, it is always preferable for the towing boat to give the tow a painter (instead of *vice versa*), which the tow should tend and keep ready for letting go in an instant. If this is not done, and the tow gives the towing vessel her bow painter, which is shackled in the bow, a hatchet or sharp knife should be kept at hand for cutting the towline in an emergency.

If the tow is heavily laden, or the sea rough, the above method brings too much strain on the stem and stern-posts of the boats; hence in such a case the painter should be toggled to a stretcher between the two after thwarts of the towing boat and to the forward thwart of the tow. To steer a boat that is towing in this manner, bear the towline over on the quarter toward which it is desired to turn, for the helm will be of little use.

Towing of ship's boats is now usually done by the steamers, which are frequently fitted with a span the ends of which are secured to either quarter. This facilitates steering and is in all respects preferable to securing the towline to the shackle in the stern-post.

When being towed astern of a large vessel, use a short scope so as to remain close under the counter, with the bow partly out of water. In casting off when there are other boats towing astern, be careful, before letting go, either to drop clear of them all with your towline, or be handy with your oars to avoid getting athwart the hawse of some of them.

Except in the case of unladen boats in smooth water, a number of boats should never be towed tandem by their painters, for in

a long tow this brings a considerable strain on stem and stern timbers of the foremost boats. To avoid this strain, the towing vessel should pay out sufficient line to reach the bow of the last boat, the other boats being secured to it by slip-lines at bow and stern.

If towing alongside, have the towline from as far forward on the towing vessel as possible; either toggle it to the forward thwart (steadying it over the stem with a bight of the painter), or pass it through the forward rowlock on the side nearest the towing vessel. Pay particular attention to the steering.

§VI. NOTES ON THE HANDLING AND CARE OF STEAM LAUNCHES OF MEN OF WAR.[1]

The laws governing the steering of a steam launch are identical with those laid down in Chapter XI for the handling of single-screw steamers.

In making a landing, whether at a dock or at a ship's gangway it is a common mistake to keep too much way and to rely upon backing full speed to stop the boat at the proper point. This is bad seamanship. The engines may and often do fail to respond promptly, and when they do respond, the sudden backing throws an undue strain upon the engines and upon the rudder-stops. Moreover, the backing throws the stern off to one side or the other—according as the screw is right- or left-handed. In coming alongside a ship's gangway, in a current, care must be taken not to catch the tide on the outboard bow, as this will sweep the bow in, forward of the landing platform and perhaps underneath it, with the result that the boat may capsize or be swamped. The landing should be made by the aid of a boat-line from forward, the boat being kept off a little from the side until the line is fast and then sheered in by the helm.

A boat may lie alongside safely in a strong current with a line from the inner bow and the helm slightly over toward the ship.

In towing, the stern of the boat should be kept well down by shifting weight aft if necessary. This keeps the propeller well immersed and gives it a good hold on the water.

[1] All remarks upon boilers in this section refer to the water-tube type.

When running in a seaway, speed should be reduced somewhat, not only to avoid shipping seas, but to reduce the strain on the machinery due to the "racing" of the screw. In running into a sea, it is possible by careful nursing to make fair speed, watching the seas and slowing or even stopping for a moment as heavy ones are seen bearing down upon the boat. If the man who is running the engine has sufficient intelligence and experience to regulate the speed in this way (assuming that he can see) it is convenient to leave it to him. If running more or less across the sea, it is well to head up momentarily for a heavy wave.

Each steam launch should have two crews, assigned to different watches in the engine room, so that there will always be one crew off duty and ready to go in the boat when the ship enters or leaves port, without calling upon men to leave their stations in the engine room. Any man of ordinary intelligence can soon be taught how to do the routine work required of the fireman and coal passer, provided that one of the mechanics of the ship exercises occasional supervision of the machinery and keeps it in repair.

When a vessel is about to enter port notice should be given one-half hour or more in advance to the fireman in charge of the launch, who should see that the boat is supplied with wood, coal and fresh water, that all parts of the machinery are connected, that bolts, nuts, keys, split pins, oil cups, steam- and water gauge lamps are in place, all usual and necessary tools on board, the boiler filled to proper level with fresh water, the cocks at the top and bottom of the water gauge open, the furnaces coaled and wooded ready to light, and the engines oiled and turned by hand.

The water used in the launch boiler should always be obtained by distilling on board. Fresh water from shore often contains corrosive ingredients or lime salts, and should never be used unless chemical tests show that it is free from these impurities.

When the launch is about to be lowered it will often be practicable to start fires at once and to have steam ready by the time the boat is in the water. As soon as the launch is in the water, if not before, the feed pump or pumps must be worked by steam, the engines turned back and forth, the

whistle, safety valve and bell tried. If at such times any of the machinery fails to work it is better to try to discover the cause by reasoning and by simple experiments rather than to use up time taking the machinery apart to see what is wrong inside, and to run the risk of twisting off studs, losing nuts and spoiling gaskets.

If an engine or pump stop-valve is detached from its stem, no steam gets to the engine and none comes out of either cylinder drain.

If steam comes out of both cylinder drains at the same time, the slide valve must leak.

If opening the drains shows that there is a good head of steam against one side of a pump piston and the piston does not move, then there may be a stop valve shut in some part of the exhaust pipe, or a stop valve in the exhaust pipe may be off its stem and kept shut by the pressure of the exhaust steam.

If on opening the drains it is found that there is a good head of steam acting against the piston and the piston does not move, shut off steam and open the drains on the water end and let out the water, then use a lever and try to move the pump piston by hand and see if it is stuck. It may be stuck from the steam piston being rusted in place, or from the piston rod stuffing box being set up too tight when the rod is worn unevenly, or the packing in the water cylinder may be too tight when the water cylinder is worn barrel shape.

If the pump starts, makes a few strokes and stops, it would indicate a valve in the exhaust closed, or a check closed.

If the pump runs but does not throw water, the causes may be:

(a). The water in the feed tank is too hot so that vapor forms in the pump. The vapor can be condensed by pouring cold water over the pump.

(b). One or more of the suction or delivery valves may be unseated or stuck open by waste under them. In this case it will be necessary to remove one or more bonnets to get at the valves.

The pump may run and throw water so that a strong jet comes out of the pet cock on the discharge side and yet no water gets into the boiler. This may be due to the pump piston or valves leaking under boiler pressure, yet not so much as to

prevent the pump throwing water under atmospheric pressure, or even a little above. If such leak is suspected, try reducing the boiler pressure to see if the pump will feed at any pressure and thus enable the boat to continue in service until opportunity occurs to repack the piston or refit the valves.

The pump may make a few strokes then gradually slow down and stop. This would indicate that the check valve was stuck, or the stop valve at the check was detached from its stem. If the check is stuck, it can often be loosened by rapping on the valve chamber with a light hammer or bar of iron. If the stop valve is off the stem, nothing can be done until the fires are hauled.

A most common cause of the failure of our naval pumps is the slipping of the tappets, and this is the first thing to be looked for.

Each type of engine and pump has its own peculiarities, which must be learned by experience. No pains should be spared to get all parts into thorough repair, and when the boat is not required for service no temporizing with machinery which works imperfectly should be tolerated. The labor required to go through the routine overhauling of all parts of the machinery is far less than the labor of repairing breakages which are sure to result from neglect of such systematic overhauling.

While the launch is alongside the ship the furnace should be fired as lightly as possible to avoid blackening the ship by the smoke that is given off when firing heavily. For the same reason the use of the steam jet is to be avoided at such times.

When the launch shoves off and gets fairly under way, the first point to notice is the vacuum, and if that is below normal, search must be made to ascertain the cause. The feed water should also be *tasted* to see if it is salt and this test repeated from time to time while the launch is in use. The firemen should carry a uniform steam pressure, fully up to that prescribed for the boat. Inability to do this shows something wrong with the engine, boiler, the coal, or with the men; and the exact reason should be discovered and the difficulty overcome. The most common causes of low steam are too heavy firing, too high water in the boiler, and tubes which require cleaning. Any kind of coal likely to be bought by men-of-war will burn well if *lumps* are selected for use in the launch. As

the men gain experience and confidence in themselves and the feed pump, they are inclined to carry water lower than the normal level because they find that the boilers steam more freely. The principal danger to be anticipated from this is that a temporary failure of the pump may result in the water disappearing from the glass, in which case there is no way of knowing how little water may be in the boiler, and it might therefore become necessary to haul the fires. While under way the water in the gauge generally rises and falls with the motion of the boat. If it remains motionless, it would indicate that the gauge was choked. If the water in the gauge shows a muddy color, or a drop of oil floating on the surface, it would be an indication that the boiler needed cleaning badly. Absolutely no oil should be used in any steam cylinder except when the machinery is to be laid up for an indefinite time, say not less than several months. In this case it should be applied by removing the cylinder and valve chest covers, wiping over the surfaces with waste dipped in mineral oil and replacing the covers. A groaning noise, which often occurs in the L. P. cylinder of a compound engine, especially when the engines are slowed after running full speed, is not an indication that oil is needed in the cylinder. When the engines are in free route, a sudden slowing down is sometimes noticed. It may be due to an increased resistance encountered by the boat from changing the course bringing the wind from astern to ahead; or to the boat leaving deep water and running into shoal water; or to the propeller fouling or the helm being suddenly put hard over; or some bearing, especially a crank pin. may be heating, or the water in the boiler going over into the engine, or the vacuum may be spoiled by an air pump valve carrying away, or there may be a drop in steam pressure from improper firing, or the water in the boiler may be run up too high and too quickly. A hot crank pin or other bearing should never occur with such engines as are now used in launches. If water gets into the cylinder to any extent a knocking sound will be heard, and the drains cannot be opened too quickly. Such an accident ought to be most carefully guarded against as it is very apt to cant the piston and bend the rod. It is caused by irregular firing, carrying the water too high, the steam too low, or suddenly speeding up the engines.

If when the engines are in free route a sudden great increase

in the number of revolutions is noticed, it is an indication that the propeller is lost or one or more blades are broken off. Slight increases may be due to the wind and change of depth of the water, &c.

In case the water cannot be kept in sight in the glass owing to failure of the pump or a leak in the boiler, it will be necessary to haul the fire. In this event a shovelful of live coals may be left in the furnace to start a new fire with. If the leak is so great that fires cannot be hauled without risk of scalding the fireman, there is no objection to putting out the fire with a bucket or two of water.

Every effort should be made to avoid the necessity for using salt water in the boilers, and to prevent it getting in from a leaky condenser. If the condenser leaks, the mixture of salt and fresh water from the air pump may be allowed to go to waste and fresh water from the reserve tanks used exclusively for feed provided those tanks carry enough water to last until the boat returns to the ship. If, however, it is necessary to use salt water, the boiler should be emptied and washed out with fresh water at the earliest opportunity, and if much salt water has been used it may even be necessary to use kerosene to remove the lime scale from the tubes.

Although the tubes of launch boilers are not found to corrode to anything like the extent that the tubes in the main boilers do, it is well always to keep the water in the launch boiler slightly alkaline by use of a small quantity of caustic soda or caustic potash in the feed from time to time when the launch is in use, and especially when the launch is hoisted; except that when the weather is so cold that there is danger of the water freezing, the boiler must be kept empty. The amount used should be just enough to turn red litmus paper blue.

In a seaway the water gauge glass must be screened, as cold spray striking the hot glass is apt to crack it. If the glass is broken the water level can be judged by using the pet cocks, or if none are provided, then by allowing the lower cock of the water gauge to drip slightly. A thumping sound is sometimes heard under the stern when the engines are running and the helm is suddenly put hard over or if the water is rough. This indicates that the bushing in the stern tube is much worn and needs renewal.

When a launch returns alongside of the ship the fireman

should report to the coxswain before the latter leaves the boat what repairs or supplies are needed in order that the officer of the deck may get prompt information on these points.

When a launch is to be hoisted on board all necessary pipe joints must be broken and preparations made for removing the engine or boiler or both if the amount of repair work required renders it necessary. As soon as the boat is secured at the davits an inspection is made of the propeller to see that none of the blades are bent, that the nut is secure with its split pin, and that there has been no corrosion of the shaft close to the propeller hub. It frequently happens that the shaft corrodes deeply at this point and then a slight blow from the propeller striking a piece of drift wood or other obstruction breaks the shaft, disabling the boat and causing the propeller to be lost. If any blades are bent they can be hammered out to their proper form. If a blade is broken off it is sometimes practicable to have a new one cast on.

An examination must be made to see if the lignum vitæ bushing of the stern tube is worn down, and if it is a new spare bushing should be fitted. If there is no spare bushing or lignum vitæ block in store, a temporary bushing may be made of anti-friction metal.

All the under-water fittings of the rudder should be examined and put in good order. The keel condenser can be tested for leaks by filling with water and afterwards draining by removing the plug provided for that purpose. A question arises as to whether or not the keel condenser should be painted. It is inconvenient of access when the boat is hoisted, and unless cleaned daily it is an unsightly object if left unpainted when the bottom of the launch is painted. Paint protects the copper from corrosion when the boat is in the water but probably diminishes its conductivity to some extent.

The ship should carry a spare engine for the launch and there should be two feed pumps in the boat. If the ship carries two launches of about the same size they should have the engines of the same size and pattern, in order that one spare engine may do for both boats and all spare parts be interchangeable.

The following spare parts are usually provided: Boiler tubes, grate and bearing bars with their patterns, water-gauge glasses, brasses for the engine, propeller shaft, propeller, keel condenser. Except the special tube expander and steam-tube

sweeper, such tools and stores as are found in the ship's storeroom will do for the launch. It is convenient to have on board in or near the machine shop, suitable pipe and connections arranged to facilitate testing the engines, boilers and pumps after they have been repaired and before they are replaced in the boat.

A water-tube launch boiler using only distilled water will usually last a cruise without cleaning. If, however, the boiler gets much scale or oil in it, the most effective way to clean it is to pump into the boiler with the feed water a few pints of kerosene lamp oil while the boiler is in use. The first effect of this will be to loosen up the dirt, and the water in the glass will appear very cloudy. Then blow down to the bottom of the glass and repeat the operation until the water in the glass gets clear.

When the engines and boilers are removed for repairs, an opportunity is offered for thoroughly cleaning and painting the bilges, repairing floor plates, water tanks, coal bunkers and such parts as are inaccessible at other times. New bearing bars and grate bars are to be fitted when required. The prolonged use of bent bars wastes coal and makes it difficult to keep up steam.

After the engines and boilers are repaired and replaced all bright work should be kept clean, the polished steel being covered with the thinnest possible coat of mineral oil, all oil holes plugged, and the engines and pumps moved by hand every day. The boiler may be painted with asphaltum or brown zinc. If the latter is used, it can be kept in excellent condition by wiping it over from time to time with oily waste. The best way to preserve the boiler is to keep it completely filled with water made slightly alkaline with caustic soda (or caustic potash) except in freezing weather, when it must be kept empty and as dry as possible, all openings being closed to prevent access of air and thus retard corrosion.

If the boiler is of such a type that it cannot be completely drained, it may be dried out by using a very light wood fire or large lamp, at the same time raising the safety valve and noting when vapor ceases to come off. In cold weather the engines, pumps, pipes and condenser must also be kept drained. It is well to provide tarpaulins for engines and boilers, putting them on in wet weather and removing them promptly when the weather clears. Launch machinery being out of sight when the

boat is at the davits, it is apt to be neglected in this as well as in other respects. At sea it is preferable to cover the polished steel-work of launch machinery with a mixture of white lead and tallow instead of the thin coat of oil, as in stormy weather it is often difficult to clean the machinery, and salt spray washes off the oil.

The officer in charge of a launch will find it convenient to keep for reference a memorandum of the size and weight of the boat, the type, weight and number or other distinguishing marks of engines, boilers and pumps, a list of necessary tools, stores, amount of coal, water and oil usually carried, the maximum speed of the boat and revolutions of engine, the steaming radius, amount of extra coal, water and oil required to cover a given distance at the desired speed, the allowable steam pressure, the usual vacuum attainable when all parts are in good order, and the greatest number of passengers the boat can carry. This data will be found convenient when about to order stores or spare parts, when instructing a new crew, or fitting out for a long trip.

Motor Boat Engines.[1]

There are now in the naval service many internal combustion engines fitted to ships' boats, varying from the small 4 horse-power "kicker" in the dory, to the 45 horse-power engine in the 50-foot launch. These engines are of the 2-cycle type in the smaller sizes and 4-cycle in the larger sizes. As a general rule the 2-cycle type is used up to 15 horse-power, and the 4-cycle above that.

Internal combustion engines may have any speed from 300 to 1000 revolutions per minute. For heavy duty boats the revolutions commonly run from 300 to 500 per minute, for those of medium speed from 500 to 700 and for those of high speed from 700 to 1000. For use in the navy, heavy low-speed engines are required, with large bearing surfaces. The revolutions should never exceed 500 per minute. As the revolutions increase the life of the engine is decreased, and no engine running at very high speed is capable of continuous running at this speed for any considerable length of time.

[1] By Lieutenant W. G. Diman, U. S. N.

In handling a boat fitted with internal combustion engines, care should be taken in making landings, the speed being so regulated in coming alongside as to prevent the necessity of throwing out the clutch when the engine is running at full speed, as to do this would cause the engine to race and in time to tear itself to pieces.

The fuel generally used is gasoline, for which tanks are provided in the boat. Any commercial grade of gasoline running from 62 to 70 proof will work satisfactorily. In cold weather there may be a little difficulty in starting on a low proof gasoline, but if a high grade is used for priming, the engine should start, and after it is warmed up the low grade fuel can be used.

The supply tanks should always be above the carburetor, so that the fuel will flow by gravity. The tanks should be thoroughly tight and fitted with a drain to lead overboard. All joints in the fuel line must be thoroughly tight and should be soldered. Strainers should be fitted in the fuel tanks and a separator in the fuel line to prevent any dirt reaching the carburetor.

Extreme care is needed in the handling of gasoline, as its vapor is explosive. It begins to vaporize at low temperatures and the rate of vaporization increases with the temperature, so that it vaporizes much more rapidly in the tropics than in cooler climates

The two most important factors in the running of an internal combustion engine are:

The *ignition* on the engine and the *mixture* entering the cylinder.

If both of these work properly, the engine is bound to run.

The ignition is generally electric and may be either of the make-and-break or the low tension jump-spark type.

It is of the greatest importance to keep the ignition perfectly watertight. No wiring should ever be run in the bilge of the boat. All ends of the wiring should have permanent marks to show where they connect, and the connections to the engine should be marked to correspond.

The plugs must be frequently examined and kept scrupulously clean.

The magneto should be placed high up on the engine to keep it out of the dirt and water of the bilge.

The engines, whatever their size, should have a covering which is perfectly watertight, as it is very important that they should

be kept absolutely dry. For small engines a detachable covering may be fitted which can be easily removed when the necessity arises for overhauling the engine. The larger engines should be placed in a separate watertight compartment.

In cold weather the carburetor and the inlet pipe are liable to freeze as a result of the vaporization in the pipe. If the air to the carburetor is warmed and the inlet pipe is jacketed by warm water or heated air, no trouble will be experienced. The jacket on the inlet pipe should be so arranged that it can be cut out in warm weather and a shutter should be fitted in the hot air pipe to the carburetor for regulating the temperature.

Three pumps should always be used in connection with an internal combustion engine equipment; one circulating, one bilge, and one air pump. No bilge water should ever be pumped through the jackets.

No chain, belt, or friction drive should ever be used in any engine equipment.

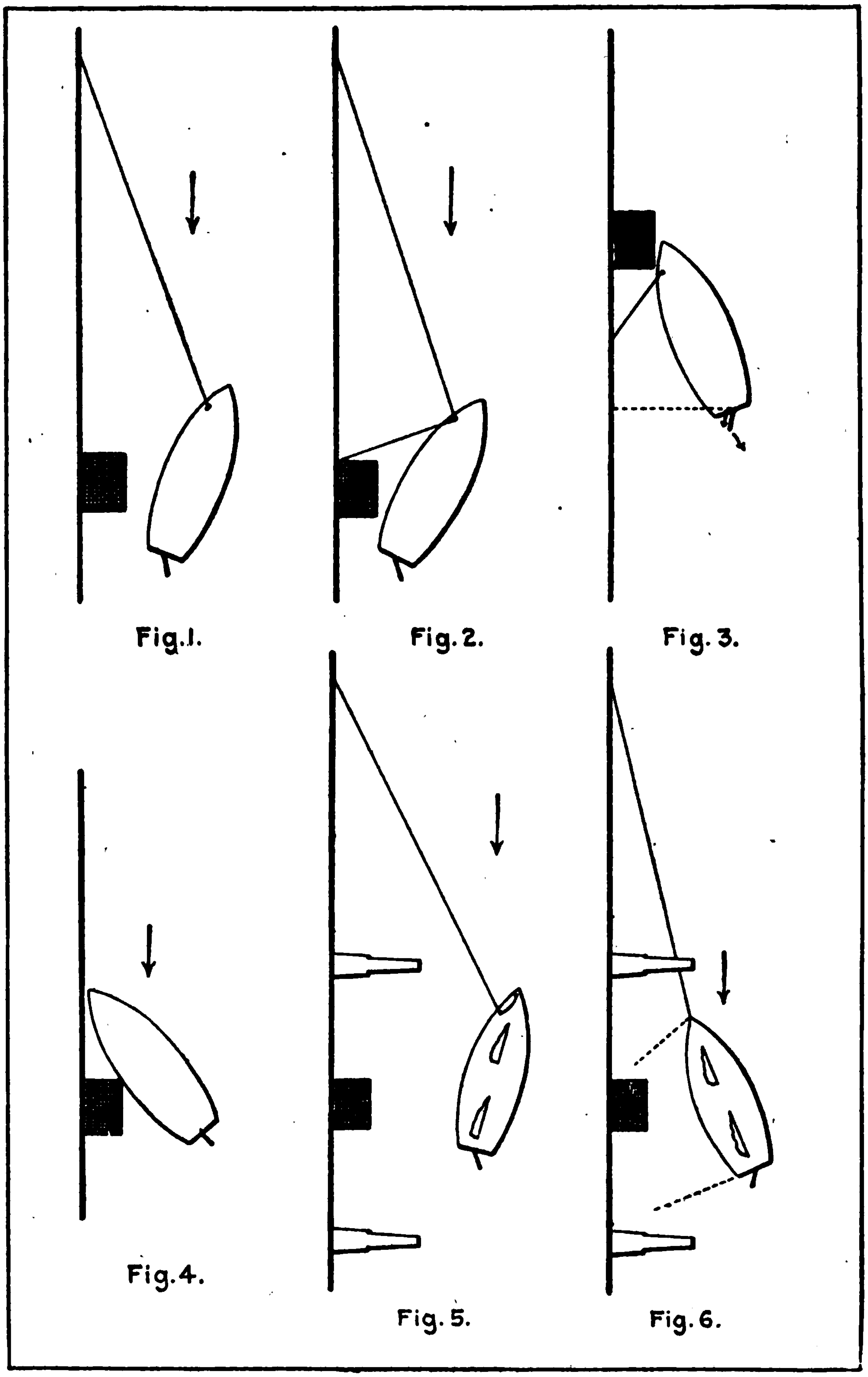
The engine should be kept well lubricated and should never be allowed to run above the rated number of revolutions or to race when coming alongside.

Handling a Launch Alongside the Ship.

A launch coming alongside a ship in rough weather or in a strong tide-way should always be *required* to take a boat-line, whether the coxswain and bowman think it necessary or not. It has come to be the custom in the navy for the crews of steamers to make their landings at the gangway by the aid of boat-hooks alone, taking hold with these of anything which may chance to be within reach, and holding on, often with great difficulty and more or less danger. This entirely eliminates the ***helm***, which is the one factor by which the whole situation could be and should be controlled. A boat lying at the gangway in a tide-way, holding on by a line from some distance forward made fast to a cleat *on her inboard bow*, can be controlled perfectly by a touch of the helm, throwing the ***stern*** out or in a little and thus catching the current on one bow or the other. Plate **66**, Figs. 1 and 2.

Boat-hooks are helpful and perhaps necessary, at bow and stern, to complete the control; but they are of altogether secondary importance if the coxswain understands that he can sheer his boat when lying in this way in a current, exactly as if she were

Plate No. 66.



HANDLING A BOAT ALONGSIDE
UNDER STEAM OR SAIL.

making way through the water. It is desirable to have the cleat for use with the boat-line as far around on the turn of the bow as is practicable, as this gives a better turning leverage for the helm and the current than if it were near the stem.

If the boat is to lie at the gangway for some time, it is convenient to use a breast line from the bowcleat to a point a little forward of the accommodation ladder, as in Fig. 2. A boat will lie like this in a tide-way with the helm half over to the side toward the ship as long as the current runs.

If for any reason it is desired to hold the bow up to the gangway, a spring may be taken from the bowcleat to any suitable point, as in Fig. 3. Then, by putting the helm over and keeping the engine ahead slow, she can be held in position without difficulty. A stern line is convenient, but is only necessary in the rather unusual case when the wind or current is from aft so that it would tend to throw the stern off too far. This plan is often convenient when we have to hold the launch at some other point than the gangway, for giving her coal which it is desired to land on the forecastle, or for putting in or taking out stores.

A fender is always fitted to the lower platform of the accommodation-ladder to keep the boat off and prevent danger of her being caught under the platform. Another fender is usually fitted forward of this to prevent boats from being set in under the ladder and athwart the lower platform (Fig. 4). A boat in this situation is in danger of being swamped. The situation is brought about by the boat having run too far ahead and being caught by the tide on the outer bow. It is a common thing to see a launch come charging up to the gangway under such speed that she cannot be stopped until she has run far ahead of the point where she should have landed, crashing against the fender and scraping along the side, while the men at the bow and stern attempt to catch something with their boat hooks by which they can check her. All this is lubberly in any case and may be very dangerous (especially when the forward fender is not in use) if there is a current tending to set her in under the ladder as above described.

It should never be forgotten in making a landing, that the engine may be slow in responding to signals, and the signal to stop should be given in time to come up to the gangway with very moderate speed.

A good coxswain, in handling a boat in a strong tide or a moderate sea, lands his boat *near* the gangway platform, but not against it, and having caught and made fast the boat line, drops in, by skilful use of his helm, and holds her just where he wants her while his passengers enter or leave the boat.

For details of United States Navy boats, see Appendix.

CHAPTER VIII

HANDLING BOATS IN A SURF.

§ I. PRELIMINARY.

The handling of boats in a surf is an art in itself, calling for special knowledge and skill such as can be acquired only by practical experience. When undertaken by those who have not this experience, the danger involved can hardly be over-estimated.

Of the various methods of landing on a flat beach which are described in the Rules of the National Life-boat Association quoted below, the safest is probably that of backing in, keeping the bow toward the surf, pulling out to meet each breaker, then backing in as fast and as far as possible *on its back.*

A surf never looks as dangerous when seen from seaward as it really is; and a boat having to land through it, should, if there is a possibility of help from the shore, await such help before attempting to go in. As, however, it is often necessary to attempt a landing where no expert assistance is available, the following rules have been drawn up and published by the Royal National Life-boat Institution of Great Britain:

§ II. RULES PUBLISHED BY THE ROYAL NATIONAL LIFEBOAT INSTITUTION, ON THE MANAGEMENT OF OPEN ROWING BOATS IN A SURF; BEACHING THEM, ETC.

In Rowing to Seaward.

As a general rule, speed must be given to a boat rowing against a heavy surf.

Indeed, under some circumstances, her safety will depend on the utmost possible speed being attained on meeting a sea.

For, if the sea be really heavy, and the wind blowing a hard on-shore gale, it can only be by the utmost exertions of the crew that any headway can be made. The great danger then is, that an

approaching heavy sea may carry the boat away on its front, and turn it broadside on, or up-end it, either effect being immediately fatal. A boat's only chance in such a case, is to obtain such way as shall enable her to pass end-on, through the crest of the sea, and leave it as soon as possible behind her. Of course if there be a rather heavy surf, but no wind, or the wind off shore, and opposed to the surf, as is often the case, a boat might be propelled so rapidly through it, that her bow would fall more suddenly and heavily after topping the sea, than if her way had been checked; and it may therefore only be when the sea is of such magnitude, and the boat of such a character, that there may be chance of the former carrying her back before it, that full speed should be given to her.

It may also happen that, by careful management under such circumstances, a boat may be made to avoid the sea, so that each wave may break ahead of her, which may be the only chance of safety in a small boat; but if the shore be flat, and the broken water extend to a great distance from it, this will often be impossible.

The following general rules for rowing to seaward may therefore be relied on:

1. If sufficient command can be kept over a boat by the skill of those on board her, avoid or "dodge" the sea if possible, so as not to meet it at the moment of its breaking or curling over.

2. Against a head gale and heavy surf, get all possible speed on a boat on the approach of every sea which cannot be avoided.

If more speed can be given to a boat than is sufficient to prevent her being carried back by a surf, her way may be checked on its approach, which will give her an easier passage over it.

On Running before a Broken Sea, or Surf, to the Shore.

The one great danger, when running before a broken sea, is that of *broaching-to.* To that peculiar effect of the sea, so frequently destructive of human life, the utmost attention must be directed.

The cause of a boat's broaching-to, when running before a broken sea or surf, is, that her own motion being in the same direction as that of the sea, whether it be given by the force of oars or sails, or by the force of the sea itself, she opposes no resistance to it, but is carried before it. Thus, if a boat be running with her bow to the shore, and her stern to the sea, the

effect of a surf or roller, on its overtaking her, is to throw up the stern, and as a consequence to depress the bow; if she then has sufficient inertia (which will be proportional to weight) to allow the sea to pass her, she will in succession pass through the descending, the horizontal and the ascending positions, as the crest of the wave passes successively her stern, her midships, and her bow in the reverse order in which the same positions occur to a boat propelled to seaward against a surf. This may be defined as the safe mode of running before a broken sea.

But if a boat, on being overtaken by a heavy surf, has not sufficient inertia to allow it to pass her, the first of the three positions above enumerated alone occurs—her stern is raised high in the air and the wave carries the boat before it on its front or unsafe side, sometimes with frightful velocity, the bow all the time being deeply immersed in the hollow of the sea, where the water, being stationary or comparatively so, offers a resistance, whilst the crest of the sea, having the actual motion which causes it to break, forces onward the stern, or rear end of the boat.

A boat will, in this position, sometimes aided by careful oar-steerage, run a considerable distance until the wave has broken and expended itself. But it will often happen, that if the bow be low, it will be driven under water, when the buoyancy being lost forward, whilst the sea presses on the stern, the boat will be thrown (as it is termed) end-over-end; or if the bow be high, or it be protected, as in most lifeboats, by a bow air-chamber, so that it does not become submerged, that the resistance forward, acting on one bow, will slightly turn the boat's head, and the force of the surf being transferred to the opposite quarter, she will in a moment be turned round broadside by the sea and be thrown by it on her beam-ends, or altogether capsized. It is in this manner that most boats are upset in a surf, especially on flat coasts, and in this way many lives are annually lost amongst merchant seamen when attempting to land, after being compelled to desert their vessels.

Hence it follows that the management of a boat, when landing through a heavy surf, must, as far as possible, be assimilated to that when proceeding to seaward against one, at least so far as to stop her progress shoreward at the moment of being overtaken by a heavy sea, and thus enabling it to pass her. There are different ways of effecting this object:

1. By turning a boat's head to the sea before entering the broken water, and then backing in stern foremost, pulling a few strokes ahead to meet each heavy sea, and then again backing astern. If a sea be really heavy, and a boat small, this plan will be generally the safest, as a boat can be kept more under command when the full force of the oars can be used against a heavy surf, than by backing them only.

2. If rowing to shore with the stern to seaward, by backing all the oars on the approach of a heavy sea, and rowing ahead again as soon as it has passed to the bow of the boat, thus rowing in on the back of the wave; or, as is practised in some lifeboats, placing the after-oarsmen with their faces forward, and making them row back at each sea on its approach.

3. If rowed in bow foremost, by towing astern a pig of ballast or large stone, or a large basket, or canvas bag termed a "drogue" or drag, made for the purpose, the object of each being to hold the boat's stern back, and to prevent her being turned broadside to the sea or broaching-to.

Drogues are in common use by the boatmen on the Norfolk coast; they are conical-shaped bags of about the same form and proportionate length and breadth as a candle extinguisher, about two feet wide at the mouth and four and a half feet long. They are towed with the mouth foremost by a stout rope, a small line, termed a tripping line, being fast to the apex or pointed end. When towed with the mouth foremost, they fill with water, and offer a considerable resistance, thereby holding back the stern; by letting go the stouter rope and retaining the smaller line, their position is reversed, when they collapse, and can be readily hauled into the boat.

Drogues are chiefly used in sailing-boats, when they both serve to check a boat's way and to keep her end on to the sea. They are, however, a great source of safety in rowing-boats, and the rowing lifeboats of the National Lifeboat Institution are now all provided with them.

A boat's sail bent to a yard, and towed astern loosed, the yard being attached to a line capable of being veered, hauled or let go, will act in some measure as a drogue, and will tend much to break the force of the sea immediately astern of the boat.

Heavy weights should be kept out of the extreme ends of a boat; but when rowing before a heavy sea the best trim is deepest by the stern, which prevents the stern being readily thrown on one side by the sea.

A boat should be steered by an oar over the stern, or on one quarter when running before a sea, as the rudder will then at times be of no use. If the rudder be shipped, it should be kept amidships on a sea breaking over the stern.

The following general rules may therefore be depended on when running before, or attempting to land, through a heavy surf or broken water:

1. As far as possible avoid each sea by placing the boat where the sea will break ahead or astern of her.

2. If the sea be very heavy, or if the boat be very small, and especially if she have a square stern, bring her bow round to seaward and back her in, rowing ahead against each heavy surf that cannot be avoided sufficiently to allow it to pass the boat.

3. If it be considered safe to proceed to the shore bow foremost, back the oars against each sea on its approach, so as to stop the boat's way through the water as far as possible, and if there is a drogue, or any other instrument in the boat that may be used as one, tow it astern to aid in keeping the boat end-on to the sea, which is the chief object in view.

4. Bring the principal weights in the boat towards the end that is to seaward, but not to the extreme end.

5. If a boat, worked by both sails and oars, be running under sail for the land through a heavy sea, her crew should, under all circumstances, unless the beach be quite steep, take down her masts and sails before entering the broken water, and take her to land under oars alone, as above described.

If she has sails only, her sails should be much reduced, a half-lowered foresail or other small head-sail being sufficient.

Beaching or Landing through a Surf.

The running before a surf or broken sea, and the beaching or landing of a boat, are two distinct operations; the management of boats, as above recommended, has exclusive reference to running before a surf where the shore is so flat that the broken water extends to some distance from the beach. Thus on a very steep beach, the first heavy fall of broken water will be on the beach itself, whilst on some very flat shores there will be broken water as far as the eye can reach, sometimes extending to even four or five miles from the land. The outermost line of broken water, on a flat shore, where the waves break in three or four fathoms water, is the heaviest, and therefore the most dangerous, and

when it has been passed through in safety, the danger lessens as the water shoals, until, on nearing the land, its force is spent and its power harmless. As the character of the sea is quite different on steep and flat shores, so is the customary management of boats on landing different in the two situations. On the flat shore, whether a boat be run or backed in, she is kept straight before or end to the sea until she is fairly aground, when each surf takes her further in as it overtakes her, aided by the crew, who will then generally jump out to lighten her, and drag her in by her sides. As above stated, sail will, in this case, have been previously taken in if set, and the boat will have been rowed or backed in by oars alone.

On the other hand, on the *steep* beach, it is the general practice, in a boat of any size, to retain speed right on to the beach, and in the act of landing, whether under oars or sail, to turn the boat's bow half round towards the direction from which the surf is running, so that she may be thrown on her broadside up the beach, when abundance of help is usually at hand to haul her as quickly as possible out of the reach of the sea. In such situations, we believe, it is nowhere the practice to back a boat in stern foremost under oars, but to row in under full speed as above described.

§ III. NOTES ON THE MANAGEMENT OF BOATS IN A SURF.[1]

From the ship a mile or two off shore, the surf may seem uniform, with no sign of a choice for making a landing. Looking at the backs of the breakers, as to leeward over the waves at sea, gives an inadequate idea of their height and abruptness. In fact, what appears to be a mere swash on the beach, may involve much danger to a carelessly handled or deeply-laden boat. Careful study will often give hints of important differences in the nature of the coast.

There may be stretches of sand beach backed by trees, the lights and shadows of which, according to their relative distances, indicate low-lying points, shallow bays, sand-choked river mouths, or even the lateral entrance of a lagoon into which the ship herself may safely pass. There may be bluffs, below which doubtless lie rocks, sometimes only shown in the churned-up surf

[1] By Lieutenant A. A. Ackerman, United States Navy.

when dangerously near. There is often a current along the shore, and this should be studied before attempting to land. Sometimes its direction changes with the tide; again it is of the nature and perhaps part of an ocean current flowing constantly in one direction. Where there are cliffs, their debris is often swept into the form of an irregular breakwater towards the lee side. This shoal, being of varying height and lacking continuity, may be of little help when covered by high water, but at low water it sometimes affords all the lee required to make an easy landing.

Narrow canons in long stretches of bluffs, or pockets in a rocky coast, sometimes mark quiet spots; the swell flowing in through deep water and breaking directly on the beach. Such places should as a rule be avoided until carefully studied. It may be possible to make use of them to land behind detached rocks or pass behind the breakers of the adjacent bluffs, but there are always sunken rocks to be feared; and the fall of the tide, or the setting in of a heavier swell, may suddenly turn the smooth seas at the entrance into heavy breakers.

A single rock, hardly far enough off shore to be shown on the chart as separated from the beach, will frequently have a quiet place in its lee, although the approach to it may at times be dangerous.

It is more difficult to choose a landing on a long stretch of sand beach; but wherever a shoal appears, or the surf stretches far out, a comparatively light surf, and perhaps even a smooth way in, should be looked for on the lee side.

Confused surf off the mouth of a lagoon or river, or the slanting breakers which sometimes run along the beach, as a rule indicate strong currents. When these are understood, a handy boat may sometimes dodge the breakers and work into smooth water with surprising ease. There is always danger, however, that the stranger may be swept down into heavy surf, or while heading up against the current or main breakers, have the boat filled by cross-seas.

Often a number of the heaviest swells follow each other in succession, after which there is a short and comparatively mild interval. Such a recurrence of quiet spells, as well as the point at which the swells become dangerous by commencing to break, and that at which they fall into harmless confusion, should be watched for and taken advantage of in landing.

The number of lines of breakers or width of surf does not always determine the difficulty of landing, as the outer lines will be much the heaviest; and if these can be avoided or passed without shipping too much water, the others will probably not be dangerous to a well-handled boat. Notice should always be taken before entering the surf, especially where it is wide, of the probable drift of the boat. It may be set by the current down among rocks or into heavy breakers.

The beach, too, may present obstacles to a safe landing, apart from the surf. At high water, it may break directly on a steep shingle beach which would be difficult to climb, even without being obliged to drag the boat clear of the breakers. If assistance could be had from on shore, such a beach might be charged on the back of a breaker and the boat hauled up clear before the next one filled it. Working with the crew alone, however, the depth of water and poor foothold would usually prevent any but the most active crew in a light boat from landing without being swamped. At the same point, an easy landing might be made on the sloping sand beach below the shingle by waiting an hour or two for lower water.

Before entering the surf at a strange locality, it is well to lie off it for awhile, noting its peculiarities and accustoming the crew to them. Dangerous breakers may form and pass, but the quieter intervals are very encouraging.

Speaking generally, a very light and buoyant boat, with a crew of as small a number as possible to handle it, will pass in and out through moderate surf with ease, while a heavy ship's boat with a powerful crew would at least take on board considerable water. Beyond a certain point, the added strength of a man does not begin to compensate for the increased weight. The requirements of a good surf-boat differ materially from those of a deep-sea life-boat, yet they are alike in some particulars. The difference lies mainly in the fact that the latter is designed to ride in a rough sea, which, since the boat rises and falls with it, does not have the battering force of a breaker. The surf-boat, on the other hand, perhaps while lying dead in the water, or carried out by oars and undertow, must meet and pierce or surmount a wall of water advancing with great velocity.

A very light and broad-beamed, single-banked, six-oared whale-boat is perhaps the type of ship's boat in which the best

proportion of power to resistance and weight moved is likely to be obtained.

If time permits, a towing-post should be fitted in the bow for veering the surf-line and this may be suddenly required to take great strain when the boat is struck by a breaker.

Besides possessing the buoyancy due to lightness of material, it would be a great advantage for the boat to be fitted with light air-tanks filling all unoccupied space and so reducing to a minimum the capacity for shipping and holding water. In fact, an extreme type of surf-boat would somewhat resemble the Esquimo's kayak, in which the boat has a cover, the only opening of which is gathered tightly around the occupant's waist.

Great *sheer* is important, and the upper strakes should flare somewhat at bow and stern to prevent their dipping under when the opposite end of the boat is lifted high on the side of a breaker. The flare of upper strakes, however, should not amount to such bluffness as will increase resistance to cutting through the crest of a wave. To permit the boat to rise and fall quickly in response to the swell, weights should be kept out of the extreme ends.

The underwater body of the boat should offer as little lateral resistance as possible to the water. Should she, in pulling out to meet a breaker, be inclined slightly from the normal and be carried back, however little, her keel, rudder-post and run would be resisted and retarded by the dead water on the front of the breaker, while the bow would be swept rapidly around turning the boat more and more broadside on, until the gunwale dips and it finally rolls over. The coxswain must in such a case attempt to pry the stern around with his steering-oar and the crew make every effort to get way on the boat and surmount the breaker before the turning action has culminated in a capsize. If the bottom of the boat is rounded and smoothed off in every direction, the water has very little hold either for turning it against the leverage of the steering-oar, or to roll the boat over should it broach-to. In fact, a light dory has been known to be swept broadside on for a long distance before a breaker without capsizing. The smooth bottom offered so little resistance to the dead water on the shore side of the breaker that there was very little tendency to trip the boat up.

High freeboard, high roomy thwarts and favorable positions for oarsmen and coxswain to exert their strength, are all important qualities. The modern navy whale-boat is a great im-

provement over the old one in these respects. It is, however, necessarily a compromise; and with very little alteration it could be greatly improved for passing the surf. Its propelling power should be nearly equally spaced about the center of buoyancy, which may be accomplished by placing an additional thwart in the stern sheets and leaving the forward thwart vacant. Passengers should sit on the bottom of the boat between thwarts; all unnecessary weights and gear should be removed. The coxswain should have a grating lashed over the stern sheet benches to give him a good foothold. Swivel rowlocks should be used; there is great danger of fouling the oars in the surf and it would then be very difficult to free one from an inserted rowlock before it had caused the boat to broach-to. Stretchers and boat-breakers should be lashed down and all other unnecessary gear dispensed with.

The subject of oars merits consideration. The steering-oar should be broad, stiff and not too long. Its exact length depends upon the boat and the height of the coxswain's platform; eighteen feet may be regarded ordinarily as a good length. A longer oar may be used to advantage at sea and its need may be felt at times in the surf; for example, when the stern is raised on the crest of a breaker and the blade of the oar barely reaches the water in the trough. On the other hand, when the boat is in a dangerous position and being carried back, a long oar is worse than useless, as it is almost impossible to keep its blade from catching in the dead water, where it tends to turn her broadside on. The other oars should also be light and stiff to permit easy handling and quick application of power. On troubled water, either at sea or in the surf, oars which exceed a certain length dependent upon the beam and freeboard of the boat are a nuisance. They cannot be handled quickly, wear the men out and are certain to strike on the back stroke or foul each other. If, in addition, they are springy, by the time the power is well applied in one direction, the boat may be turned or tilted and most of the stroke lost. No hard and fast rule can be given for the length of oars; that had better be determined by actual test in each particular boat. It will seldom, if ever, however, be found advisable to employ in a single banked boat, an oar longer than twice the beam at the thwart plus the freeboard at the oarlock.

Whichever way of landing is adopted, a conical drag, towed ten to twenty fathoms astern, will be of great assistance. It

should have a tripping line to invert it when it is not required to check the boat. Too much reliance should not be placed upon the drag, however, for though it will always *assist* to keep the boat pointed fair to the breakers when the line is hauled in briskly by a couple of men, there is not the positive assurance of holding the boat that is given by a surf-line attached to a well-bedded anchor planted outside the surf.

There are occasions when the use of such a surf-line and anchor is invaluable. Among them may be noted the landing in a large or unwieldly boat; landing with a weak or inexperienced crew, or in high surf where it is necessary to return, or in any case where it seems pretty certain that the crew will be unable to maintain control over the boat with their oars. On the other hand there are certain disadvantages connected with the use of the surf-line. There is a current along almost every beach and if the surf is wide, a boat going out may drift down so far that when the dangerous breakers are reached, the line to the anchor leads broad off the bow and tends to turn the boat rather than steady it head-on to the breakers. Should a boat using a surf-line be capsized in the outer surf, the coils of line will probably knot and tangle so as to prevent the boat from drifting in.

Whenever the line is used, a hatchet should be kept close to the bowman's hand with which to cut the line should it become necessary. In going in where the surf is wide or there is a current, the line may be used to pass the outer breakers and then abandoned. If a bucket is tied to the end, it may be picked up again and used on going out. The anchor should be buoyed with spare oars or other gear so as to recover it should the boat be obliged to abandon the line or to cut it in coming out.

All unnecessary articles are taken out of the boat. The water-breaker is tightly plugged and lashed down, as are the stretchers and buckets for bailing. The men shift into light clothes without shoes. If the weather is sufficiently cold to require it, dry clothing may be carried in the air-tanks, which should, however, be carefully inspected and all unnecessary articles removed. A hatchet, copper tacks, sheet lead, and roll of felting should also be carried for use in case the boat is stove. If the beach is distant, it may be possible to go under sail, or to be towed by another boat so as to keep the men fresh. The presence of a second boat would also be of great assistance, if it was used to distribute oil over the water abreast

the landing, for although the quieting effect of oil is much less marked upon a surf than upon deep sea waves, there is abundant evidence that its value is considerable, especially in the comparatively deep water where the outer and most dangerous breakers form.

A second boat lying outside would be an encouragement to a crew pulling out from shore, and might be of great assistance to the probably exhausted men after their trip through the breakers.

In going out, the time of start, though important, is less so than when coming in, as it may be possible to pull half-way out without taking water on board or meeting dangerous surf. If a surf-line is used, take the boat up the beach until it appears that when carried down by the current and hauled out at the same time it will reach the dangerous space with the line fair to the anchor. Station two active, powerful men to haul in the line, as more progress will be made in this way than if they took oars. The four after-oarsmen steady the boat, standing in the water opposite their thwarts, oars apeak. Put the passengers aboard, haul taut the line, and commence walking out the boat, the coxswain at the stern. As soon as the boat leaves the bottom the men climb in and take their oars, pointing them to prevent drift until ready to start. The intention is to so time the arrival of the boat at the outer line that no heavy breakers will be met at that point. Varying width of surf and speed of boat may make this difficult of attainment.

At the start the men, pulling and hauling, force the boat rapidly through the water. Irregular waves splash into the boat; later they become too large to be pulled through without taking much water on board. It is then best to check headway, tauten the line, and peak oars as the breaker passes. So the boat works out, obviously passing many more breakers than when coming in. Gradually the filling boat becomes sluggish, difficult to pull and steer. In this condition it may be capsized if only slightly turned, and it may now be better to go back, bail out, and try again, than to struggle on and risk an almost certain capsize in the heavier breakers.

A properly pointed boat may succeed in passing through a breaker that it cannot hope to ride. The water may fill it to the thwarts, in which condition it will capsize at a touch, but once clear of the breakers it may be bailed out and enabled to meet the waves of any ordinary sea in safety.

CHAPTER IX.

GROUND TACKLE.

§ I. ANCHORS.

The form of anchor commonly used throughout the world from the beginning of the last century up to about 1875 was, in most essentials, that shown in Plate 67. It is true that double-fluked anchors resembling those now so familiar were proposed as early as 1850, but they were slow in making their way, and it was not until about the year above-named that they began to come into anything like general use. They are now almost universally used by steamers, and the prejudice which long existed against them in the minds of seamen is rapidly dying out.

When an old-fashioned anchor is let go in water fairly deep, it strikes the bottom crown first, and immediately falls over until it rests on the end of the stock, the arms lying horizontally. From this position any drag of the chain to one side capsizes or "cants" it, pulling the stock down horizontally upon the bottom and pointing one of the flukes fair for biting. As the drag continues, the fluke is forced into the ground, and if the anchor is well designed, the heavier the pull the deeper the fluke goes down —provided sufficient length of chain is given to keep the pull approximately parallel to the bottom. For this reason, quite as much as because of the "cantenary" that comes from a long scope, it is important to use plenty of chain, particularly when the anchor is taking the first hold. In good holding ground, anchors frequently bury themselves completely. This tendency of the old-fashioned anchor to work into the ground under a pull is one of its most valuable characteristics, and one not possessed by any of the double-fluked types.

It is a common mistake to think of the holding power of an anchor as due entirely to the area of the palm. If this were the case, the merits of an anchor might be determined very simply. But the fact is that a large palm may be an actual disadvantage. No doubt the cross-sectional area of that part of the anchor which is buried has much to do with the resistance, but so has

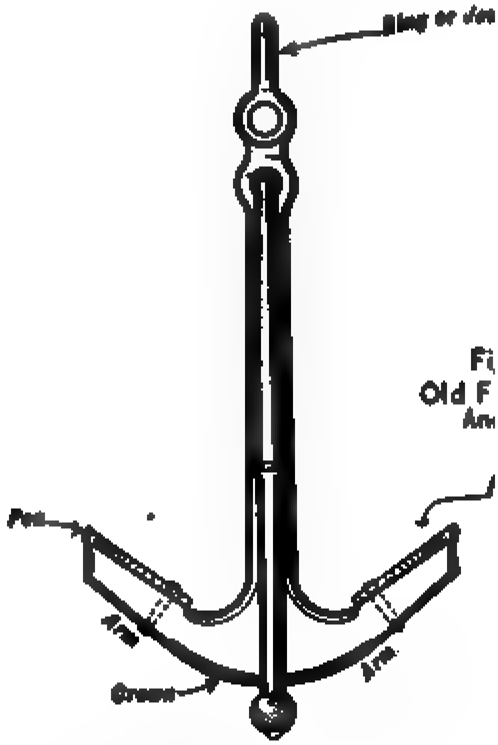
the friction of the whole surface upon the soil by which it is surrounded and which tends to pack around it and press in upon it from all sides.

If, now, an anchor drags—and it usually does so slightly in the act of taking hold—an excessively large palm breaks up the ground through which it moves and carries the soil along, leaving a broad furrow behind through which the arms and crown move without resistance. A small and well designed palm, on the other hand, permits a *flow* of the soil, which closes in behind and keeps a constant friction on the other parts of the anchor. Another disadvantage of a large palm is in its tendency to become "shod" in a clayey soil. Such a soil sticks to all parts of the anchor, but especially to the palm; and if the anchor starts after having once held, it carries along with it a shapeless mass of mud which is for the time being a part of the anchor. This adds to its weight, but does away with all chance of its biting again, and there is nothing to do in such a case but to pick up the anchor and let go another.

In the double-fluked type the palms are always large, and this type trusts for holding to their area alone. Moreover, the arms are necessarily straight—or nearly so—and lack the tendency to work downward which is so important a feature of the older form.

The anchor shown in Plate 67, represents fairly well the most approved design of the old type. The palm is of medium size, the arms shaped to the angles most favorable for biting, and the cross-section of each part carefully designed for maximum strength in the direction of the strain to which it will be subjected. All edges are chamfered off to reduce the wearing of the chain as its bight rides over the anchor, and all re-entering angles are rounded as much as possible.

While double-fluked anchors are not necessarily stockless, most of those in use are so, and claim this feature as a merit. It certainly adds greatly to the convenience of handling and stowing, and this is the ground on which the patent anchor makes its strongest appeal to favor; but so far as holding is concerned, it is unquestionably a disadvantage. As a ship swings around her anchor, there are many times when the chain leads off to one side and upward with a pull upon the ring tending *to roll the anchor over* and so break out the fluke (or flukes). A similar tendency will exist in the case of a direct pull, if the flukes of a



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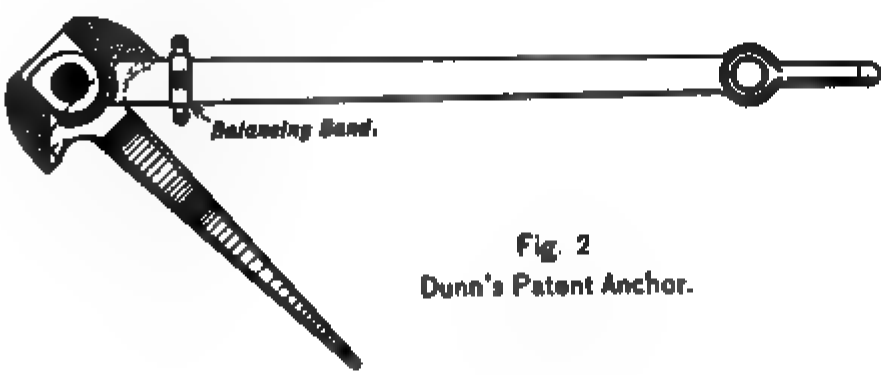


Fig. 2
Dunn's Patent Anchor.

U. S. NAVY ANCHORS.

THE BALDT ANCHOR.

patent anchor encounter different degrees of resistance. A stock prevents rolling over under these conditions, whether with a patent anchor or an old-fashioned one, and many seamen insist that it is hardly less useful in this matter than in canting. One of the best known of the patent anchors (Martins, Plate 69) has a short stock as a concession to this view, and nearly all double-fluked types may be had with stocks if desired.

Plate 69 shows several of the best known types of double-fluked anchors. The following features are common to them all.

1st. The arms are pivoted upon the shank and can swing from thirty to forty degrees on either side.

2nd. The palms are in the plane of the arms instead of at right angles to it.

3rd. It results from this construction that both flukes should bite if either one does.

4th. To insure that the flukes shall bite, the arms carry, at the crown, a projecting shoulder with a sharp edge, which takes on the bottom and throws the arms downward.

They are catted and fished, if at all, at a single operation, by a pendant (or purchase) hooked into a balancing link. In most cases, they are hoisted direct to the hawse-pipe and stowed there.

TYZACK'S.—In place of a shoulder at the crown for throwing the arms downward, this anchor has a third fluke there which not only tilts the others but assists them in holding.

SMITH'S.—This type has two tilting shoulders, one at the base of each arm, instead of a single one at the crown.

HALL'S has its tilting shoulder distinct from the arms and pivoted upon them, while they in turn pivot upon the stock.

DUNN'S (Plate 67).—This is an American type, and is much used in the United States Navy. The shank engages the arms by an enlarged head, so that its holding strength is independent of the pivoting pin. If this pin breaks, the anchor continues to hold as well as before.

BALDT'S (Plate 68).—This type is also much used in the United States Navy. It resembles the Dunn, but differs from that type in the method of connecting the arms to the shank.

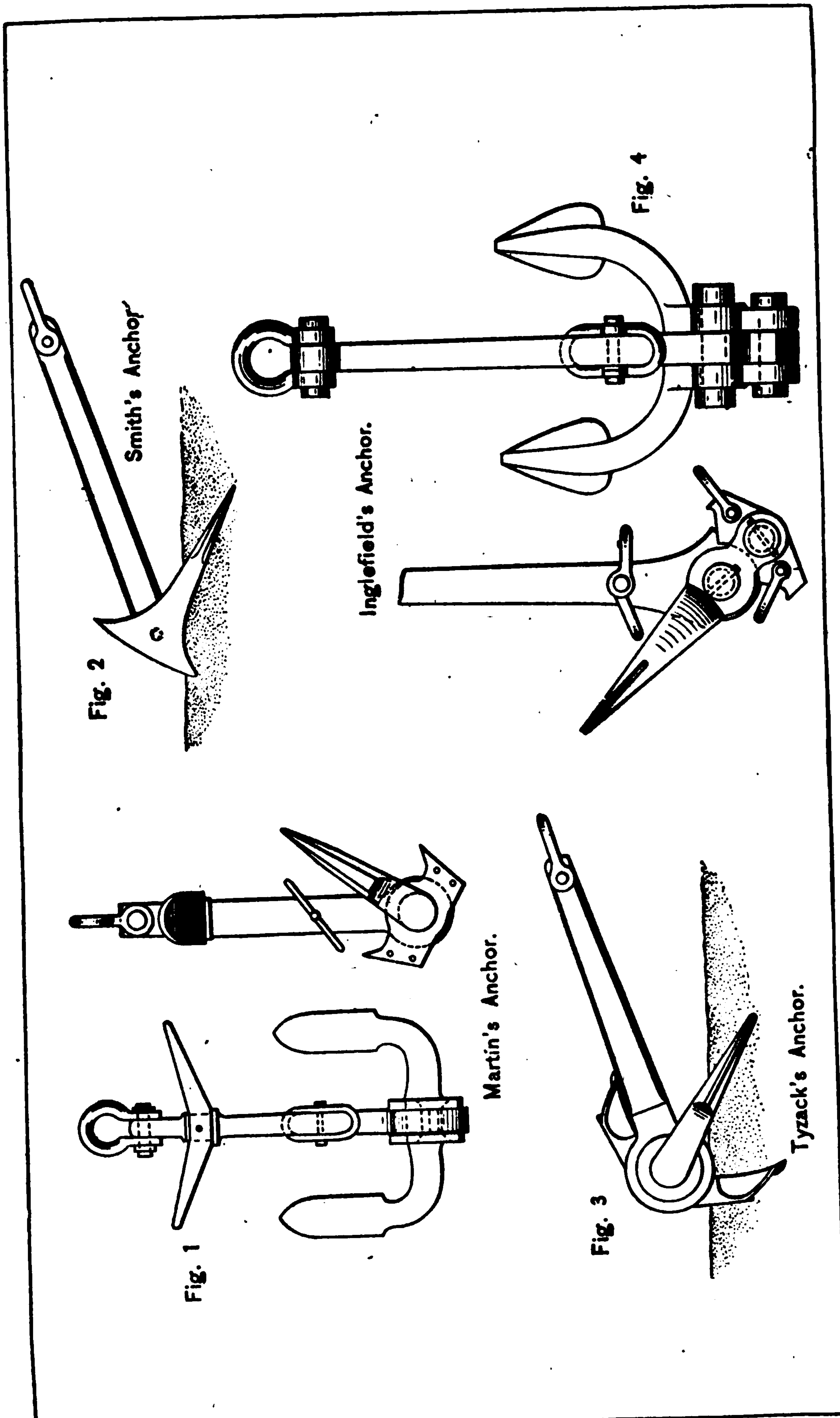
Patent anchors have unquestionably very great advantages in convenience of handling and stowage. If carried on the bow, they are catted and fished more simply than the old type and usually much more quickly; they stow compactly, and have no stock or fluke projecting to interfere with the gun-fire of a man-of-war

or to be a menace in case of collison. In modern ships they are usually hoisted to the hawse-pipe and the shank hauled inside, while the flukes lie close up to the side of the ship. In some cases, the hawse-pipe is made large enough to take in the whole anchor. Both of these arrangements do away with catting and fishing—an advantage which cannot fail to be appreciated by any officer who has ever had to cat and fish an old-fashioned anchor while steaming (even dead slow) into a head sea. It is, moreover, a great advantage to have the anchor always ready for letting go and to be able to drop it from the hawse-pipe instead of from the cathead, as the sudden jerk with which it brings up on the chain in the old-fashioned way not only strains the cable unnecessarily, but is apt to start it running out so fast that more or less slack chain is paid down on top of the anchor, with danger of fouling it.

A "housing" anchor must of course be stockless and must be without a "balancing link." It must also be very strong in the shank to stand the strain which comes from canting over the lip of the hawse-pipe as the ring and shank are dragged inside. The question of the strain due to canting in entering the pipe is especially serious in men-of-war of recent date in which the hawse-pipes are made almost horizontal with a view to getting the anchor, when stowed, so high above the water that it will not drive a cloud of spray on board in pitching into a sea. This strain, although a maximum on the shank, which has to stand the leverage of lifting the flukes, is very great also on all other parts of the ground tackle, including the windlass.

Where the anchor stows in the hawse-pipe, it is let go either by slacking the friction-brake of the windlass, or, better, by knocking adrift the link of a slip-stopper; it being a common practice in recent ships to leave the anchor hanging by a stopper rather than by the brake. In letting go from a stopper, it is well to light forward a few links of slack chain to make sure that the anchor shall start at once when the link is knocked clear.

A further advantage of the patent anchor is its comparative freedom from danger of fouling. As it lies on the bottom, it presents no projecting parts, like the stock and fluke of the old-fashioned anchor, for fouling the chain. The absence of projections, moreover, does away with the danger that the ship may be bilged by grounding on her own anchor in shallow water.



PATENT ANCHORS.

It may be laid down as a rule that the patent anchor always needs a longer scope of chain to bite and hold than does the old-fashioned one. This is because a slight upward pull on the ring drives the old-fashioned fluke into the ground but breaks out the flukes of the other type.

Anchors are usually made of cast steel, recent improvements in the manufacture of that metal having made it sufficiently reliable to justify its employment for this purpose. But the stocks, rings, pins, shackles, balancing bands and other fittings should in all cases be forged, and in the case of housing anchors, the shanks also.

Patent anchors, stockless, have been definitely adopted for all purposes in the United States Navy except for kedges and for the anchors of torpedo-craft.

The types at present used are the Dunn (Plate 67) and the Baldt (Plate 68).

All bower and sheet anchors will hereafter house in the hawse-pipe except on such of the older ships as cannot be fitted for this.

All housing anchors will have shanks of forged steel.

The following will be issued to battleships and battle cruisers:

2 Bowers.

1 Sheet.

1 Stern.

2 Kedges.

Boat anchors as necessary.

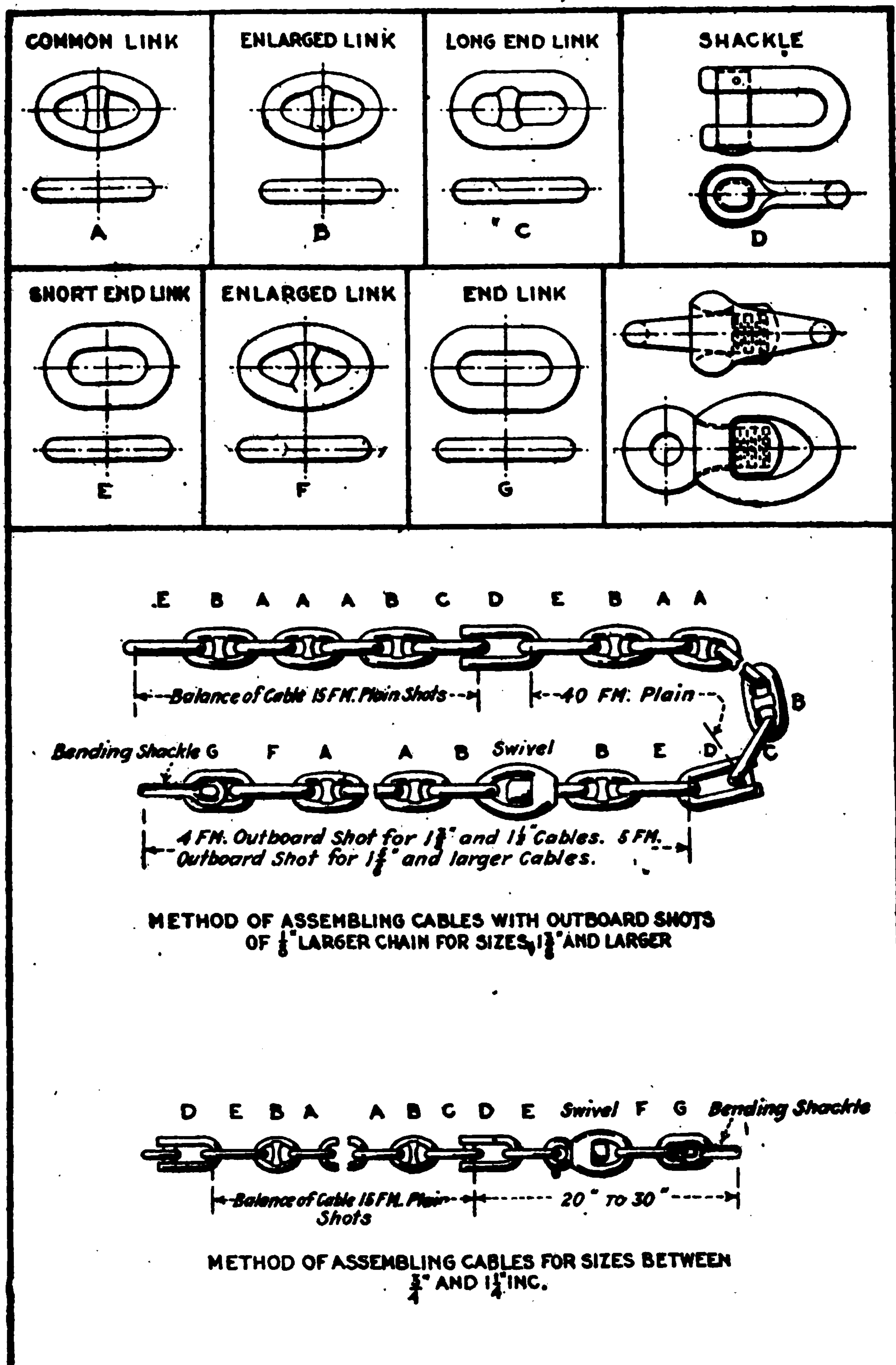
§ II. CHAIN CABLES. (Plate 70.)

Chain cables are made of wrought iron on account of its *ductility,* the property by virtue of which it resists shocks and admits of being readily welded; in which characteristics it excels steel. Steel has a higher tensile strength per square inch than wrought iron, but that fact is not sufficient to offset the points in favor of wrought iron.

The iron for chain making is purchased under specifications demanding certain chemical and physical characteristics in order to insure the greatest uniformity.

Extract from Specifications.

This iron, as received, must have a tensile strength of not less than 49,000 pounds per square inch nor more than 52,000 pounds per square inch, an elastic limit of about 60 per cent of the breaking strain, an



DETAILS OF CHAIN CABLE
UNITED STATES NAVY

elongation of at least 30 per cent in a length of 8 inches, and a contraction of area of at least 40 per cent.

Bolts cut from 1 per cent of the bars rolled from this iron to 2½-inch round iron for cable making must stand bending cold until the sides are brought parallel, and separated from each other not more than ½ inch without showing signs of rupture. Such bolts must also have a tensile strength of not less than 48,000 pounds when rolled direct from 1⅝-inch square bar into a 2½-inch round bar. Bolts similarly rolled must also stand bending at red heat until the sides are close together without any signs of fracture. Such bolts as may be nicked and broken cold by slow bending must show fibrous.

One per cent of the bolts rolled from this iron to chain sizes will be made into test specimens of three links and this "triplet" must stand a pull of at least 37,500 pounds to the square inch of the sectional area of the link in a 2½-inch chain, and 41,000 pounds to the square inch of sectional area of the link in a 1¼-inch chain; in other sizes the breaking strain to be proportioned between these limits.

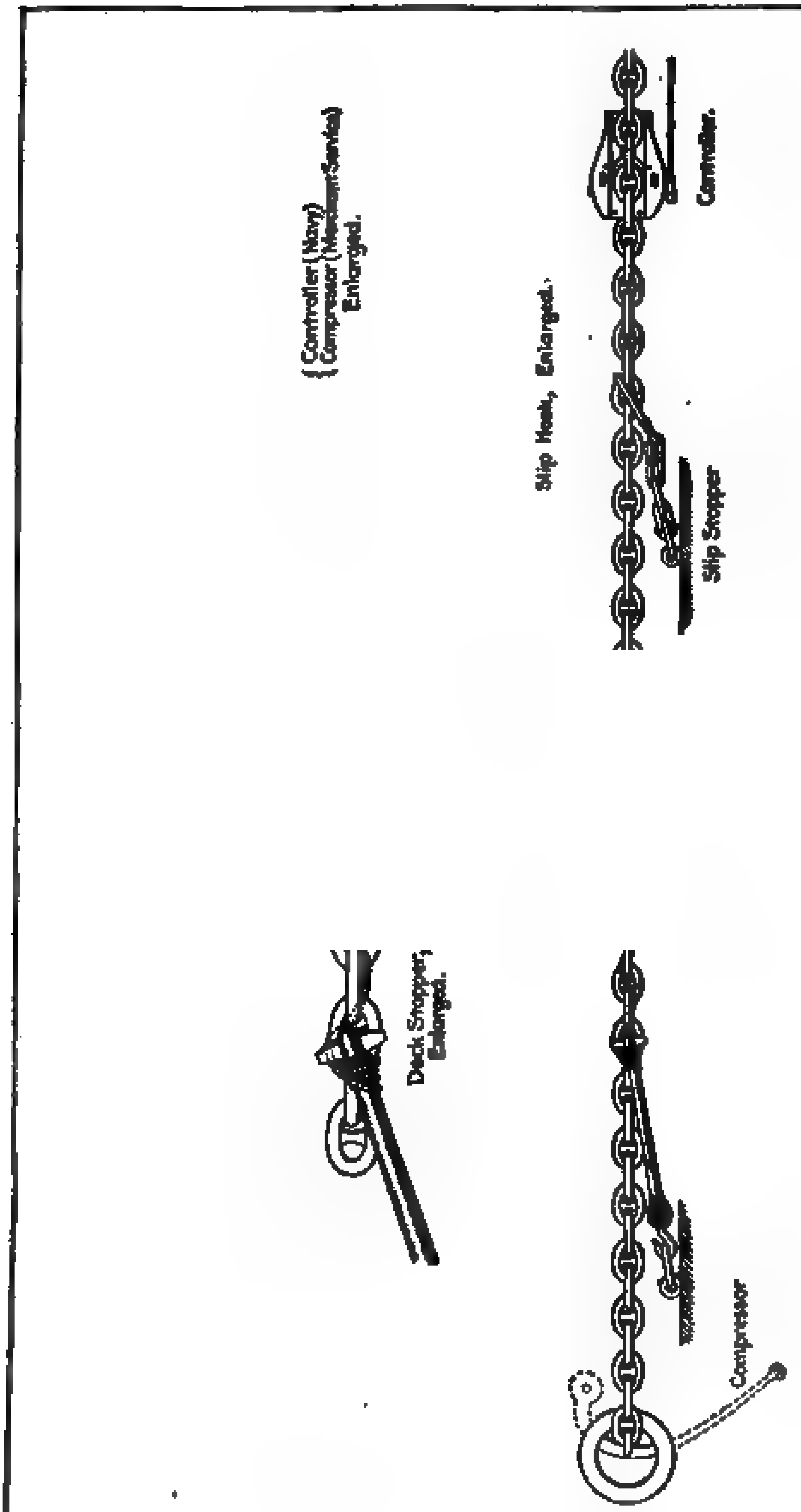
The bars are rolled to the size required for the links and the chain bolts are sawed from the bars while still hot as they come from the rolls. Their ends are sawed at an angle of 30°, or "scarfed," and they are then bent to the form of the link, by a machine, before losing the original heat from the rolls. The ends are left sufficiently open to admit of threading the link in hand through the one previously made. The link having been threaded into place, the scarfed ends are closed down upon each other, a welding heat is taken, and the weld is made.

The link is bent to such a shape that after the weld has been made the width shall admit of inserting the stud. The links are closed down on the stud while hot, and the contraction in cooling holds the stud in place.

The studs are drop-forged from mild steel. The principal use of the stud is to prevent the cable from kinking. The experience of years of testing chain at the Navy Yard, Boston, is that the stud does not add any strength to the link.

All chain made at the Navy Yard, Boston, is end-welded; that is, the weld is made at the end of the link. The two sides of the link are therefore the same, and thus will bear a greater strain than if the links were welded on the side as in the case of English chain, and of chain made commercially in the United States. Chains are now welded by a machine, with a marked gain in time, labor and efficiency.

During the process of manufacture, three links are cut from the shot and tested to destruction in a hydraulic testing machine,



GROUND TACKLE.

the capacity of which is 800,000 pounds. After the shot is completed it is given a proof strain, which is 90 per cent of the tensile strength of a single side. The ultimate or breaking strain of a link is about 160 per cent of the single bar of which the link is made.

Size of Chain. Chain is designated as to size by the diameter of the iron of which the common links are made, standard sizes running by sixteenths of an inch from ¼ inch to 3⅝ inches, this last being the size issued to the largest battleships of the United States Navy.

Lengths of Chain. Chain is manufactured in comparatively short lengths, known as "shots." The standard length of an ordinary shot in the United States Navy is 15 fathoms. In the British Navy it is 12½ fathoms. In the present United States Naval practice, the first or outboard shot is of approximately 5 fathoms, and the second one of 40 fathoms, the object of this arrangement being to prevent the possibility of having a shackle on the windlass while breaking ground. The five-fathom shot is ⅛ inch larger, and its two outer links from ¼ of an inch to a full inch larger, than the other parts of the cable, this having been found necessary to provide for the shock to which this part of the cable is subjected in letting go.

Shackles. The shots of chain are connected by "connecting shackles" (Plate 70), the bowed end of the shackle being always placed forward (toward the anchor). This helps it to engage the ribs of the windlass wildcat and prevents it from catching on the controller and the hawse-pipe as it runs out.

The bolt (or pin) of the shackle is sometimes round, but more often oval, in section. In the latest United States Naval practice it is egg-shaped. This shape gives an increased bearing surface for a given cross-sectional area, and also makes it impossible to put the bolt in the wrong way—an important consideration in handling ground-tackle at night. The bolt is held in place by a forelock pin driven in a hole through the bolt and the enlarged ends of the shackle. This forelock pin is sometimes of wood—preferably hickory—well coated with white lead and driven home tightly. For unshackling, these pins are either backed out, or sheared by a smart tap of a hammer on the end of the bolt. A better practice is to use a forelock pin of steel, which should be tinned to prevent corrosion. A common practice for

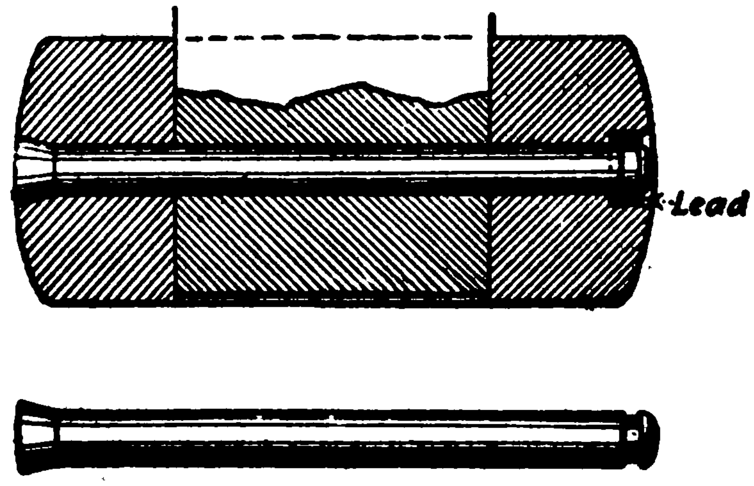


Fig. 1
Details of Forelock Pin and Lead Keying Ring for Shackles.

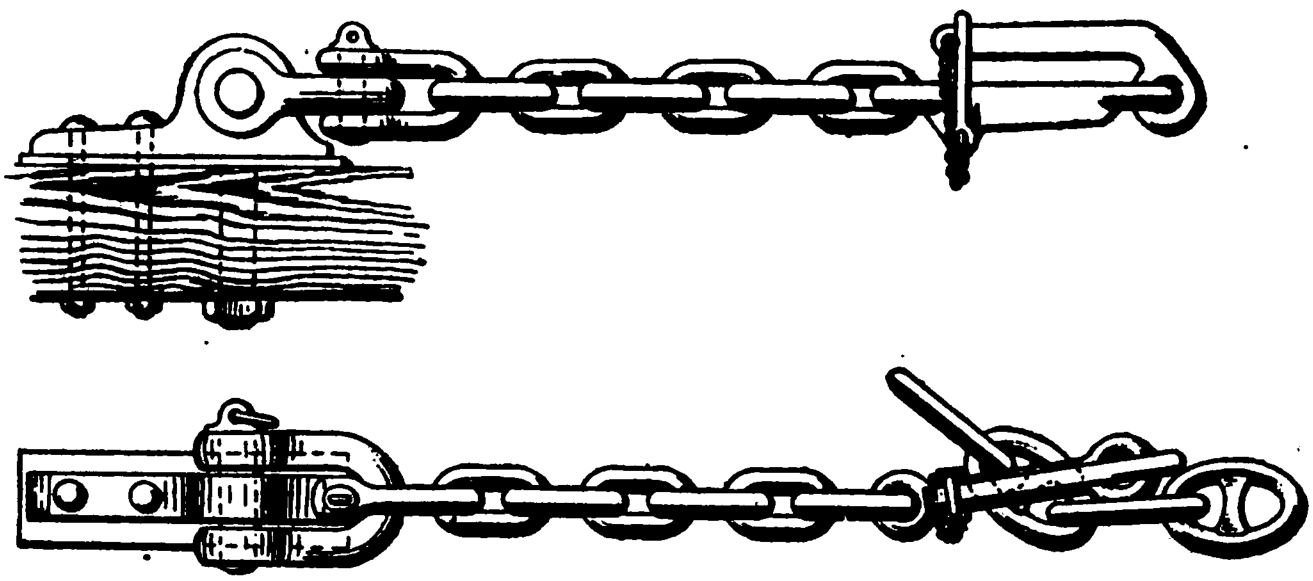


Fig. 2. Slip Stopper.

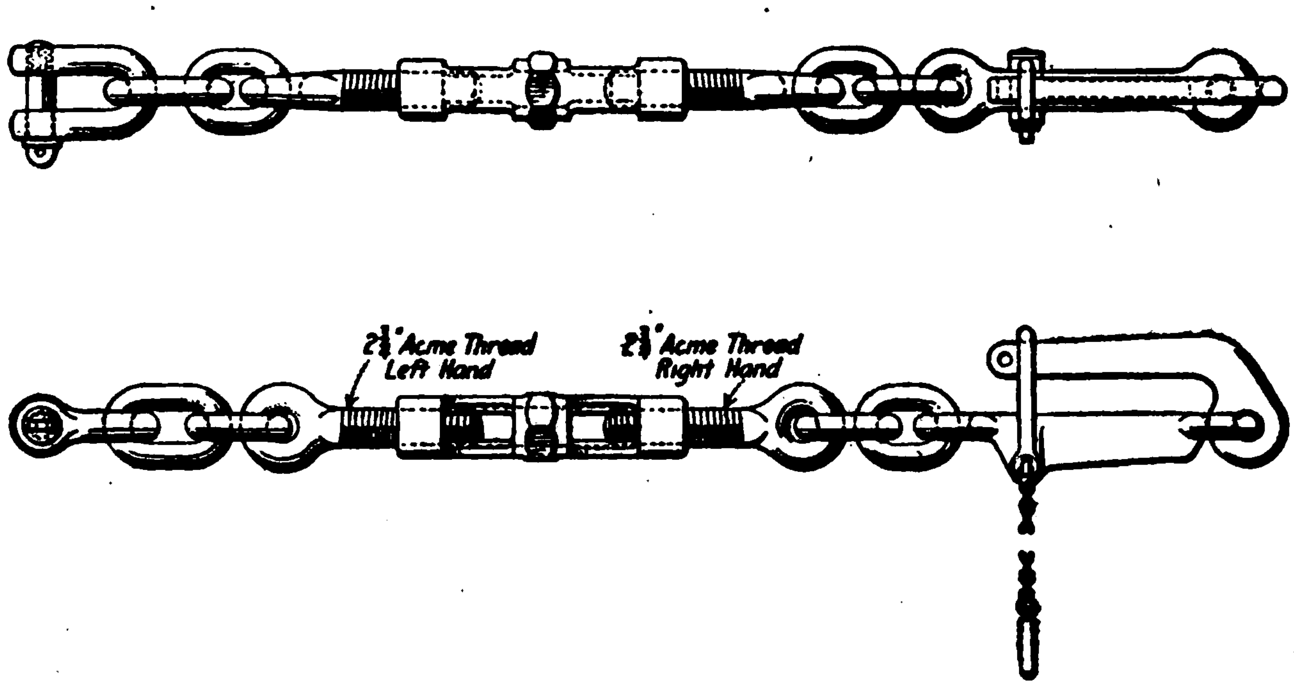


Fig. 3. Housing Chain Stopper, U. S. Navy.

DETAILS OF GROUND TACKLE.

securing the forelock pin is to jam it at each end by a pellet of soft lead upset into the hole in the shackle.

The practice in the United States Navy is to use a forelock pin made of steel, tinned, and held in place by a keying ring of lead, which is upset, by a special tool, into a groove around the end of the forelock pin, the other end of this pin having a countersunk head (Plate 72). In unshackling, the keying ring is sheared.

To admit of slipping the shackle into place, the end link of each shot of chain is made without studs.

The "bending shackle," at the anchor end of the cable, is much larger than the connecting shackles and differs from them somewhat in details. In the case of anchors which stow on the bow, the bolt of the bending shackle sometimes projects beyond the body of the shackle, but this will not do for a housing anchor, as the projecting bolt would jam in entering the hawse-pipe.

Shackles should go to the capstan flat so that the strain is taken on each eye, with no tendency to open the shackle. The eye of the shackle has been designed so that it is stronger than the round.

Swivels. To prevent the accumulation of turns as the ship swings about her anchor, swivels are used (Plate 70). Formerly there was one of these in every length of chain, but they gave much trouble in passing around the capstan (being too large to take the sprockets), and their number has been gradually reduced until now not more than three or four are used in the cable, and in United States Naval practice only one is used, this being placed in the first (5-fathom) shot.

Length of a Cable.[1] The total length of a cable may be anywhere from 90 to 200 fathoms. In the United States Navy the standard length has long been 120 fathoms, but this has recently been increased for battleships and large cruisers to 150 fathoms, and for the bower cables of the latest Dreadnaughts to 180 fathoms, the sheet cables remaining at 120 fathoms. Three cables are carried, two for the bower anchors and one for the sheet anchor.

In the British Navy the bower cables are of 187½ fathoms, made up in fifteen lengths of 12½ fathoms each. The sheet cable consists of eight lengths of 12½ fathoms, making 100

[1] A "Cable's Length" as a unit of measurement is always 100 fathoms, this being 8 shots of 12½ fathoms each.

fathoms in all. In small vessels, the sheet chain is replaced by a wire hawser.

In the merchant service (British), the total length of chain to be carried by ships of different tonnage is prescribed by law, as is also the size; but there is no requirement with regard to the length which shall be used on one cable. The lengths used are always much less than those for men-of-war.

STOWAGE. The cables are stowed in "chain lockers" which are usually in the hold, below the windlass. The inner, or "bitter" end of the cable is first of all brought up from the locker and made fast to a beam or other accessible place by a slip-hook or some other arrangement which, while holding securely, shall admit of easy slipping, or of bending on an additional length. In merchant vessels, the bitter ends of the two bower cables are sometimes shackled together. This is a bad practice, as it leads to delay and difficulty when an additional length is needed on either cable, or when it becomes necessary to slip from the bitter end, as may happen in an emergency, after the cable has been veered away to its full length.

The chain is stowed, as it is paid below, by "tierers," with the aid of chain-hooks, hook-ropes and, in the case of heavy chains, of tackles hooked in eye bolts in the deck above the chain-locker.

This operation of "tiering" the cable is of very great importance as the cable if paid down rapidly and stowed carelessly is likely to kink in running out and may jam in the chain pipe, with very disastrous results. It should be stowed regularly and symmetrically in long flakes fore and aft, without kinks.

Watchfulness must be observed to make sure that no one is in the locker when the anchor is let go or the chain veered, and that no gear of any kind is in the way.

The cables of the largest men-of-war are too heavy and cumbersome to be handled by tierers. They are accordingly stowed in deep and very narrow lockers, where there is little chance of kinking, and tierers may be dispensed with. A reliable man should, however, be stationed at the locker both in heaving in and in letting go, to make sure that all goes clear.

BENDING THE CABLE. The chain is bent to the ring of the anchor by a shackle similar to the shackle used between the lengths of the cable, but somewhat larger. Its details, as well

as those of the links immediately adjoining it, vary considerably. Plate 70 shows the method used in the United States Navy.

MARKING. Cables are marked by turns of wire on the studs of certain links, the number of the link, counting studded links only, from the shackle on each side, indicating the length. Thus at the end of the first length from the anchor there is *one* turn of wire on the stud of the *first* studded link from the shackle on each side; at the end of the second length, *two* turns on the *second* studded link, etc.

In United States Naval practice, the turns of wire as above described are usually supplemented by painting one or more links with some light color, usually white. The paint shows up well at night and can often be seen at some distance below water. While the practice varies on different ships, the following is a common and convenient system:

At	15	fms.	(No shackle), 1 white link.
"	30	"	" 2 " links.
"	45	"	3rd studded link each side of shackle, *white*. Studs of painted links wrapped with 3 turns of wire.
"	60	"	4th studded link each side of shackle, *white*. Studs of painted links wrapped with 4 turns of wire.
"	75	"	5th studded link each side of shackle, *white*. Studs of painted links wrapped with 5 turns of wire, etc.

In weighing, as the chain is hove in, the painted links are wiped dry and re-painted.

OVERHAULING A CABLE. Cables should be overhauled frequently, the chain being roused up on deck, and each shackle, link, and swivel carefully examined. Flaws may be detected by the ring of the metal when struck with a hammer. A defective shackle may be easily replaced by a spare one, but a bad link condemns the whole length of chain in which it occurs—except that a missing stud may be replaced without much difficulty. Every length should be unshackled, and shackle bolts and pins cleaned and coated with white lead and tallow. If a pin is found rusted in, the rust may be cut with turpentine, or the pin broken. Swivels should be well oiled, and worked until they turn freely

and without grinding. All marks should be verified, and renewed if necessary.

Perhaps the most favorable of all opportunities for overhauling the cables is when a ship is in drydock. Here the anchor and cables may be lowered into the dock, where they can be handled much more easily than on the forecastle.

The cable having been thoroughly overhauled and the chain-lockers cleaned and painted, the bitter end is made fast, and the chain is paid below and carefully stowed.

EXTRACT FROM UNITED STATES NAVY REGULATIONS.

"On all vessels the Commanding Officer will have made at least once a year a careful examination of the bower and sheet chains throughout their entire length. They will be ranged on deck by shots, cleaned, scaled and inspected for defects, shackle and forelock pins refitted and greased or white leaded, and identification marks restored if necessary. The chain will then be carefully painted. As the shot nearest the lockers are the least used, one of them, or two in the case of battleships and cruisers, providing the shots are in good condition, should be shifted at these times to a position inboard of the 40 fathom shot, in order to distribute the wear more uniformly along the entire length of the chain. If serious defects are discovered they should be brought to the attention of the Bureau of Construction and Repair, and if it is not practicable to make immediate replacement, the defective shots should be shifted to the bitter end of the cable. A note of this examination should be entered on the next following quarterly report."

Not all officers are aware that every shot of navy chain bears upon the side of its forward link a serial identifying number and the year of manufacture.

One of the most frequent and serious accidents to which cables are subject is the springing of a shackle by a strain tending to open out the end.

Such a strain may come from a bad fit on the windlass in heavy heaving, or from the accident of the shackle being subjected to a heavy stress while lying across the outer lip of the hawse-pipe. A pin may be broken in some such way as this, and the bolt loosened, without the injury becoming apparent on casual inspection.

It is a good rule to have not only every shackle but every link examined each time the anchor is weighed. If time does not admit of a careful examination of the individual links, these may be struck with a hammer. The sound will tell if any flaw exists. Time can always be found to look carefully over the shackles.

Make-up of Cable. The make-up of a chain cable for the United States Navy is as follows (Plate **70**):

Beginning with the outboard, or anchor end:

(a) Bending shackle.

(b) First shot of cable, five fathoms in length, of material ⅛ inch larger than that used in other lengths of the cable, with a swivel near the inner end.

(c) Second shot of cable, of forty fathoms, connected with (b) by a shackle.

(d) Other shots of cable, each of fifteen fathoms, in number sufficient to make up a total length of 120, 135, 150, or 180 fathoms, and connected by shackles.

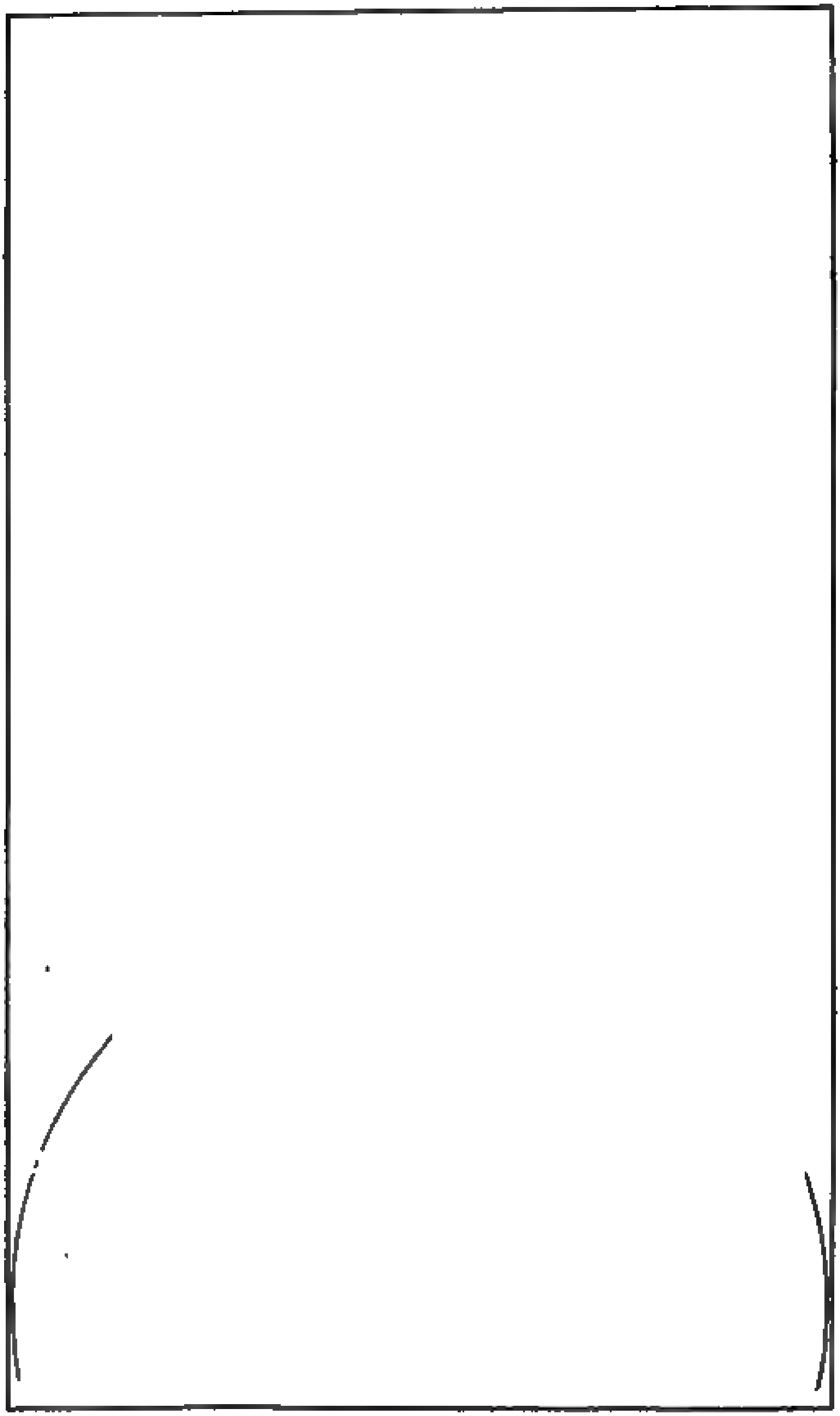
The arrangement of the first two shots, of five and forty fathoms respectively, prevents danger of having either a swivel or a shackle on the windlass during the heavy heaving connected with breaking ground.

The use of 150 or 180 fathoms on each of the bower cables makes it practicable to moor with 60 fathoms on each cable, and this is the length now commonly used in mooring.

In handling the anchors, bending and unbending chain, etc., the five-fathom length which comes next to the anchor is usually not unbent, as it is easier to work with the end of this than with the ring of the anchor direct.

WEIGHT AND STRENGTH OF CHAIN.

Diameter of Material.	Weight per fathom.	Breaking stress.	Safe-working load.
Inches	*Lbs.*	*Tons.*	*Tons.*
¼	3½	2	½
½	15	6½	1½
¾	34	15	4
1	58	27	7
1¼	90	42	10
1½	130	60	15
1¾	180	82	20
2	240	108	27
2¼	300	136	34
2½	360	168	42
2¾	440	200	50
3	500	243	60



FORECASTLE OF U. S. S. IDAHO.

Plate No. 74.

FORECASTLE OF A MODERN BATTLESHIP.

U. S. S Wyoming.

Approximate Rules for Weight and Strength of Chain.

D=DIAMETER OF MATERIAL OF LINKS.

Weight per fathom	$=D^2\times 60$ lbs.
Weight per 15 fathoms	$=D^2\times 900$ lbs.
Breaking Stress	$=D^2\times 60{,}000$ lbs. $=D^2\times 27$ tons.
Safe Working Load	$=D^2\times 15{,}000$ lbs. $=D^2\times 7$ tons.

The bower and sheet cables of battleships and armored cruisers range from 2½ inches for the *Oregon* and *Missouri* classes to 3½ inches for the latest Dreadnaughts.

§ III. CAPSTANS, WINDLASSES, ETC.

Strictly speaking, a capstan differs from a windlass in that its axis is vertical while that of a windlass is horizontal. The terms are, however, often confounded; and there is a tendency of late to call everything a windlass which is fitted with sprockets for engaging the links of a chain, and everything a capstan which takes a rope around a barrel. Thus we hear of "horizontal capstans" and "vertical windlasses."

Most of the modern contrivances for weighing anchor have horizontal shafts and are therefore properly windlasses. The latest type of windlass in the United States Navy has a vertical shaft (Plate **74**), so that in spite of what has been said above, we must regard the term *"windlass"* as fully established to designate a *capstan* when used, with power, for handling an anchor and chain cable. This leaves the term *"capstan"* for those appliances which take a *rope* around a *barrel.*

BITTS (Plate **71**) are heavy cylindrical iron castings firmly secured to the deck.

In connection with ground tackle, they act as guides for the cable in running out, and in some cases for securing the cable. In old-fashioned ships, the cable was taken around the bitts, with one or two turns, as a precaution in riding at anchor. They are seldom used for this purpose now.

Bitts are fitted aft, for securing lines in towing.

STOPPERS (Plates **71, 72, 74**), of which there are many different forms, are used to hold the chains when the anchor is down, to relieve the strain on the windlass, and for securing the anchors and cables at other times.

Plate No. 75.

U. S. S. BATTLESHIPS KEARSARGE AND KENTUCKY.

American Ship-Windlass Co.

Where no bitts are used, the stoppers must be strong and consequently heavy. For the largest ships they are of chain, with slip-hooks for holding the cable, and are shackled to heavy ringbolts on the deck. When fitted in this way they are known as "slip-stoppers." In smaller ships they are of rope, usually hemp, with a "stopper-knot" or an iron toggle in the outer end and a lanyard for lashing to the cable.

SLIP-STOPPERS, in addition to their use for holding the cable when riding at anchor, are used with "housing anchors" for *securing* the anchors in their housed positions in the hawse-pipe. When used in this way the stopper usually has a screw turnbuckle for drawing the anchor close up into the hawse-pipe. In this case it is called a "screw-stopper," or "housing-stopper." Plate 72.

In large ships, with housing anchors, the anchor is usually let go from the slip-stopper by knocking off the link of the sliphook. If the distance from the hawse-pipe to the chain-locker is considerable, as it usually is in a large ship, it is found necessary to have a few links of slack chain abaft the stopper to insure that the anchor shall start to drop when the link is knocked clear. With the chain taut all the way to the locker, the mere dead weight of the anchor will not start it.

CONTROLLERS are designed primarily to control the chain by catching it link by link as it comes in, so that if it slips on the capstan or if anything else goes wrong inside, no harm will be done. Each horizontal link, as it comes in, drops down abaft the lip of a heavy block, while the vertical link next forward of it drops into a slot in the top of the same block (Plate 71).

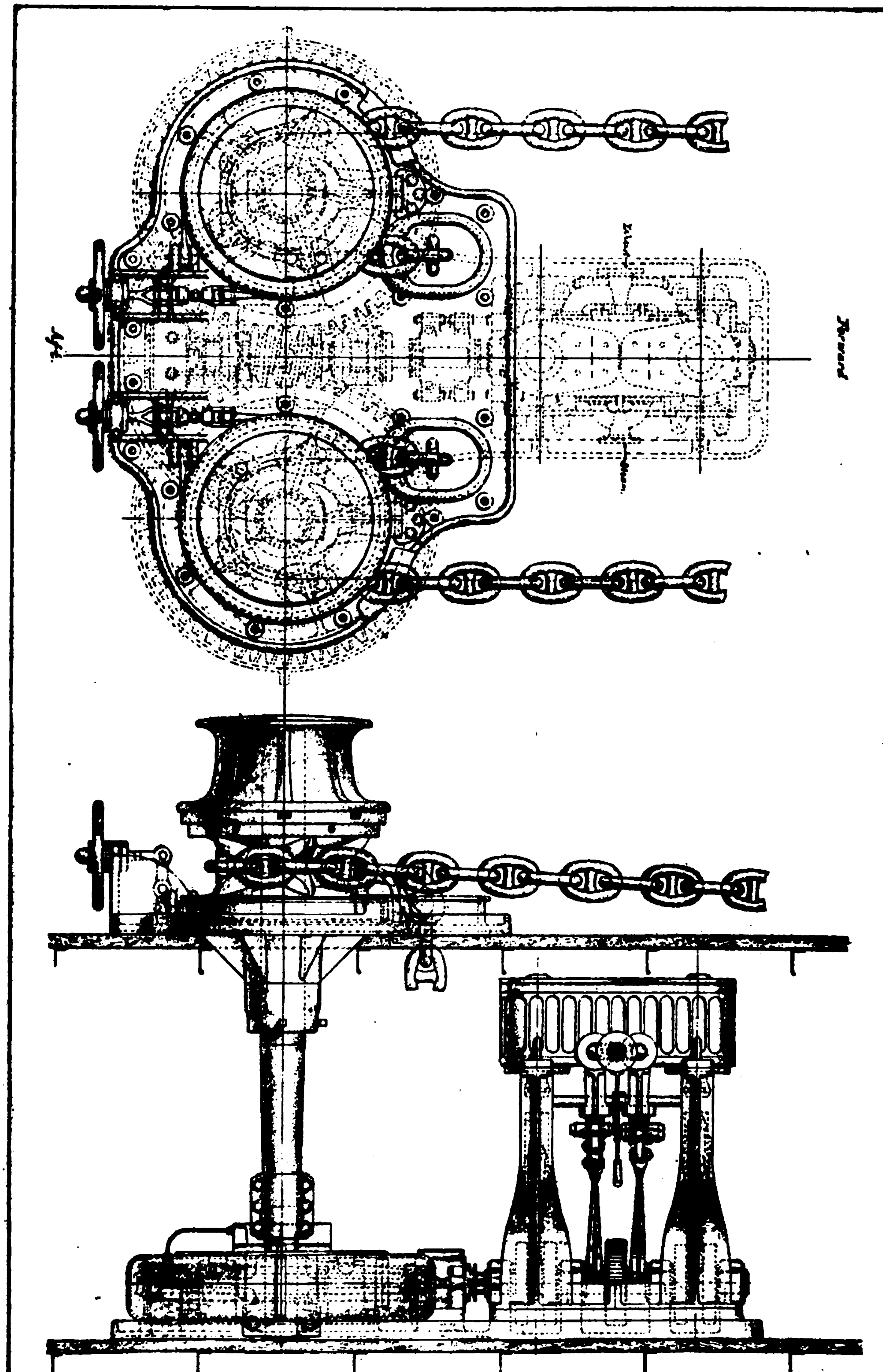
A controller is sometimes used to hold the chain for surging, and even, in some ships, for riding. In such cases it should not be trusted alone, but should always be backed up with a stopper. It is not advisable to ride in this way with the ordinary controller.

Controllers are no longer used in the United States Navy.

In the merchant service, the controller is called a *compressor*.

Certain types of controllers are fitted with heavy coiled springs designed to take up the jerks on the chain that come in riding at anchor in a seaway. Such a controller, supposing it to be strong enough for its work, should be an excellent thing to ride by. Merchant steamers frequently tow by their controllers (compressors).

Plate No. 76.



HYDE STEAM WINDLASS.

WINDLASSES.

There is a great variety in the windlasses used for handling anchors and cables in modern steamers, almost every firm of shipbuilders having a type of its own. Certain general features, however, are common to them all. A steam-engine turns a shaft, either horizontal or vertical, on which is mounted a "wildcat" or "chain-grab," over which the chain passes and by which its links are engaged. The wildcat turns loosely on the shaft, but may be rigidly secured to it by some form of connection, and much of the individuality of different types of windlasses lies in the nature of this connection. The wildcat is secured to the shaft for heaving the chain in or out, but is disconnected in veering chain and in riding by the windlass; being controlled, when so disconnected, by a friction brake.

On some ships, a dummy wildcat is fitted. This cannot be connected to the windlass engine; but as it has a friction-brake, the sheet-chain, which is the one connected to the dummy, can be easily controlled when the anchor is let go, although it must be taken to the windlass for heaving up.

In most cases, a capstan (frequently on the deck above) is connected with the windlass in such a way that the two can be worked either together or separately.

A type of windlass well known in the United States, and used on many vessels of the United States Navy, is shown in Plate 75.

This windlass is horizontal and mounted on heavy bitts firmly bolted to a bed-plate which furnishes also a foundation for the engine by which the windlass is operated. The connection between the windlass and the engines is a worm and worm-wheel gearing, the worm being placed beneath the worm-wheel and close to the bed-plate;—an arrangement which admits of supporting it solidly and of running it in a bath of oil. The cogs of the worm-wheel are cast on a rim and bolted to a driving head which is rigidly keyed to the shaft. This arrangement admits of replacing the gearing if it becomes worn, without dismounting the windlass. The windlass shaft can be arranged to carry two, three or four wild-cats or chain-grabs. These are mounted loosely on the shaft but can be locked to driving-heads which lie alongside them and which are rigidly connected with the shaft. When so locked to driving-heads, the wild-cats turn with them and with the shaft, for heaving the chain in or out.

Figs. 3 and 4 show two plans for locking and unlocking the wild-cats. In both methods, the locking-pawls are actuated by a ring, loosely mounted upon the driving-head. This ring can be turned either forward or backward by a lever shipping in holes provided for it at a number of points on the ring. As the ring turns, it throws out or draws in a series of pawls which

are mounted on the driving-head and which, when thrown outward, engage projecting lugs on the wild-cat. In Fig. 3 the pawls are pivoted on the inner face of the driving-head, under the overlapping rim of the wild-cat. To move in and out they are fitted with bolts which engage an eccentric groove in the locking ring. As the ring is moved in one direction, these grooves throw the pawls outward and cause them to engage the lugs on the inner periphery of the wild-cat, thus locking the latter to the driving-head. The reverse motion of the ring draws the pawls in and unlocks the wild-cat. The pawls and lugs in this device are concealed by the overlapping rim of the wild-cat.

In the device represented by Fig. 4, a solid block is moved in and out by a rib running eccentrically along the outer face of the locking ring. In this device (which is later than that of Fig. 3), the whole locking mechanism is in plain sight.

When the wild-cat is unlocked it revolves freely, allowing the chain to run out, except as it is controlled by the friction-band brake fitted to the outer rim of the wild-cat. This may be set down so hard as to hold the wild-cat absolutely, or it may be applied with just pressure enough to control the chain, allowing it to run out with any desired degree of speed. The delicacy of control thus afforded is one of the most valuable features of this type of windlass. It admits of snubbing the ship on her chain without shock even when she is going with considerable speed.

Directions for Using the "Providence" Steam Windlasses on the U. S. Battleships "Kearsarge" and "Kentucky."

When coming to an anchorage see that everything is in order for letting go. Be sure that the chain-stopper pawl or block is up and the wild-cat is unlocked. Place a trusty man (with an assistant when the chains and anchors are large and heavy) at the hand wheel to work the friction band. When ready, let the anchor go and as it drops screw up the hand wheel slightly, so that slack chain will not run out and foul around the anchor stock.

In nipping the anchor do it gradually in all cases.

To lock the wild-cat, bear down on the locking lever; to unlock, lift up on the lever.

When desiring to heave up the anchor, lock the wild-cat to the windlass, see that the friction bands are slacked off, and that the chain-stopper pawl or block is down.

When desiring to reverse the windlass for the purpose of overhauling the chain, it is only necessary to reverse the engines. With this type of engine, no pawls are used.

Directions for Keeping the Windlass in Order.

Keep all the bearings well oiled. Oil holes and automatic lubricators are provided for all the bearings. They should be kept free from dirt and regularly inspected. Use none but the best sperm oil for bearings. A mixture of equal parts of black lead and tallow makes the best preparation for the worm-wheel and worm to prevent cutting and wear.

The windlass should never be run without the gear teeth and worm being

well slushed with black lead and tallow, a can of which is sent with every machine, and which should be replaced with more of the same material.

When the windlass is not in use, the cylinders and steam-chest drips should be left open, so as to drain all the condensed steam from the engines.

When starting a windlass for the first time it should be handled carefully and under the direction of an experienced person. Run it at first without any load till the bearings and worm and worm-gear teeth are perfectly lubricated.

Another type much used in the United States Navy is the Hyde Steam Vertical Windlass.

This windlass (Plate 76) consists of two wildcats with locking gear, compressor bands, and warping heads. Each wildcat is supported on a separate vertical shaft, the whole being self-contained on a substantial iron bed in which there are openings leading to chain-pipes. Connection between windlass and engine is made by a worm keyed to a continuation of the crank shaft. This worm drives two worm gears, each of which is keyed to the lower end of one of the vertical shafts. Located between the worm and engine is a thrust-bearing adjustable for wear in either direction. An oil pump operated by engine shaft throws a continuous flow of oil on the worm.

Some of the advantages claimed for this type of windlass over the horizontal type are that less space is required on the upper deck and the engine with gearing is not exposed to the weather. The strain exerted by the chain is close to the deck, and the chain has a more secure hold on the wildcat.

In some windlasses, the friction brake takes the shape of a disc or a set of discs keyed on the shaft but movable along the line of its axis by a screw or lever, by means of which they can be jammed up more or less tightly against the face of the wildcat.

If the windlass has no wildcat for the sheet cables, the ship should be fitted with *bitts* for working these.

Plates 73 and 74 show the forecastle of a modern battleship, with all details of ground-tackle.

LETTING GO.

In modern ships with heavy ground-tackle, the bower anchors, when housed in the hawse-pipe, are secured by deck-stoppers, the outer one of these, just abaft the hawse-pipe, being a slip-stopper, engaging the chain by a slip or "pelican" hook.

In preparing to let go, the other stoppers are taken off and the windlass brake slacked off, leaving the anchor hanging by the slip-stopper alone. If the drift between the hawse-pipe and the chain-locker is considerable, it is well to rouse up a few links of chain, lighting the slack forward to a point just abaft the stopper.

Care must be taken that all is clear below decks and in the chain-locker. A reliable man should be stationed near the locker and made responsible for this.

To let go, the link of the slip-stopper is knocked loose with a sledge.

As the anchor may hang in spite of the slack links above mentioned, it is well to have an anchor-bar at hand for shaking up the chain, especially if anchoring in formation when a delay of a few seconds may be serious.

Where the anchor is carried on a bill-board, as in Plate 79, the lashings used in securing the anchor for sea must first of all be cast off, leaving the anchor hanging by two chains, each secured at one end by a lashing and at the other by a link which engages a trigger-bar, by tripping which both chains are released simultaneously.[1]

In some cases anchors carried on a bill-board are lifted by a "fish-tackle" hooked to a swinging davit and lowered until they hang by the cable from the hawse-pipe, from which position they are let go from a slip-stopper exactly like the housing anchors already described.

Modern ships are not usually fitted with riding-bitts, but when they are, it is well to bitt the chain *if the anchor is to be let go from the bow.* This saves the wildcat from the sudden shock due to the tautening of the chain as the anchor drops, and assists the friction brake in snubbing;—the operation which puts the ground tackle to the severest test that it is ever called upon to stand. Old-fashioned ships were brought-to by nipping the chain with the compressor; and as there was here no "give," the shock of bringing the vessel up was sometimes very severe upon both the compressor and the cable. It is one of the most

[1] In passing the stoppers of the anchor, care should be taken that the end which is to unreeve in letting go is brought in *over* the anchor, so that in letting go this end will be thrown out and down. If passed underneath, it will be thrown up and in as the anchor drops and may swing in with dangerous violence.

important advantages of modern windlasses that they provide a means of bringing-to gradually and easily.

The anchor should always be let go with the ship moving slowly, either ahead or astern, to avoid paying the cable down on top of the anchor.

With the old-fashioned anchor, it is generally better to be going astern, at least when anchoring head to tide or wind, as otherwise the bight of the chain is likely to foul the anchor as the ship drops back. If conditions are not such that she will drop back over the anchor, this point is of no consequence; and with a patent anchor (which has no projecting fluke to be fouled) it is not important in any case. There are some advantages about letting go with headway on, especially when it is desired to anchor at a definite point—standing in, for example, on a given bearing and anchoring when another bearing is on. It is much easier to do this with the ship going ahead and thus under control; and no other way is practicable if it happens that the line on which we run in is more or less across the wind or tide.

In case of a number of vessels anchoring together in formation, it is essential that all should let go while going ahead with some speed, and it becomes a matter of considerable interest to know what speed is safe under these conditions. It will be found that almost any ship running at a speed of four or five knots, with steam available for twelve knots, and backing with full power as the anchor is let go, can be brought up at 45 fathoms without undue strain on the cable.

If obliged to let go at a higher speed, or if for any reason it does not seem safe to check her with so short a scope, *the chain should be allowed to run until she loses her way sufficiently to make it safe to snub her.* There is no great harm in running out 75 or even 90 fathoms of chain and afterward heaving in to a shorter scope; and it should be remembered that even in cases where the headway has to be checked by bringing up on the chain, the danger is less with a long scope than with a short one, for the same reason that makes a long scope safer in riding to the anchor.

The danger connected with letting go while under considerable headway is often overlooked, for the reason that *the damage resulting from it does not necessarily show itself*

at once. The excessive strain may distort and weaken the links of the cable, without actually parting them. The result is that the cables may give way at some future time under a comparatively moderate stress. In the British Navy it has long been the custom to let go with considerable headway, especially in mooring; but in October, 1908, an order was issued by the Admiralty forbidding this practice and stating that experience has shown that the parting of cables in H. M. ships has been due mainly to the gradual weakening to which they are subjected by anchoring and mooring with too much way on.

It is a general practice for ships approaching an anchorage to slow to half speed when some distance from the point for letting go and later to stop their engines and let the speed drop as it may, the actual speed at which the ship is moving when the anchor is let go being a matter of guess-work within rather wide limits. It would seem more reasonable to slow to the speed which is considered safe for letting go, while far enough from the anchorage to be sure of settling down to this speed (as definitely fixed by the number of revolutions) by the time the anchorage is reached, and to stop the engines as the anchor is let go. This is especially advisable where ships in squadron are anchoring together, as it not only fixes definitely the conditions for anchoring but makes it far easier for the ships to keep their distance from each other. (See Chapter on "Keeping Station and Manœuvring in Squadron.")

Where it becomes necessary to anchor in very deep water, it is absolutely essential that the ship should be going dead slow. If several ships are anchoring in formation, they should anchor in succession, not simultaneously. As the anchorage is approached, at very slow speed, the anchor may be lowered gradually until it is within a few fathoms of the bottom, and then let go, only enough headway being maintained to avoid paying the chain down on top of the anchor. The details of handling the windlass for anchoring in this way will vary with the type of windlass used, but it will be found that even where the ship is dead in the water, and where the anchor is let go with only a few fathoms of drop, *the weight of the chain alone will cause it to run out very violently.* In extreme cases, where the depths run, as in Puget Sound ports for example, up to 40 and 50 fathoms, it is advisable

not to "let go" at all, but to "back out" the chain by the windlass engine, until the anchor is on the bottom and the necessary scope of chain out.

The danger of fouling the anchor by paying the chain down on top of it is not as serious in the case of a patent anchor as in one of the old type, but it is much better to avoid this if practicable, in any case, by having a very little way on the ship at the instant of actually placing the anchor. The sooner the way can be checked after this instant, the better.

WEIGHING.

In heaving in, the windlass and the cable may be relieved by a judicious use of engines and the helm, and the officer on the bridge should be kept informed of the direction in which the chain "tends" or "grows" on the bow, and whether it is taut or slack.

In a ship with a ram bow, the chain will sometimes get across the ram. It may be cleared by stopping the windlass and going astern a few turns with the proper engine.

If there is much tension on the chain when a shackle or swivel comes to the wildcat, there will be trouble from the slipping of the chain, as swivels and shackles are necessarily larger and longer than the links, and cannot take the lugs of the chain-grab so securely. This trouble may always be expected when the depth of water is such that a swivel or a shackle is on the wildcat in breaking ground or after the anchor is aweigh. It may be met by clapping a "hook-rope" on the cable at once and taking this to the "gypsey" or the capstan. If neither of these is convenient, a deck tackle may be hooked on and well manned. If the drift between the windlass and the locker admits of such a thing, a tackle abaft and below the wildcat is very helpful, tending not so much to relieve the stress as to jam the chain down into its place on the wildcat, and so to prevent slipping. In ships where this difficulty is to be anticipated, it should be prepared for as part of the regular preparations for getting underway.

Shackles and swivels, with the links adjoining them, are, in cables of standard manufacture, made of lengths and sizes carefully proportioned to the rest of the chain and to the cable-holders with which they are to be used. Improvements in this direction and in the design of the cable-holders have greatly reduced the

difficulties described above. In cables like the latest ones for the United States Navy, where there is neither a shackle nor a swivel between five fathoms and forty-five, it is unusual for either of them to come to the windlass in breaking ground.

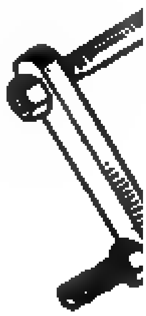
STOWING ANCHORS.

The arrangements for stowing anchors in modern ships differ widely with different types of ships. A number of such arrangements are shown in Plates **77, 78** and **79**. A comparison of the figures there given brings out clearly the inconvenience of a stock (as an obstruction to gun-fire) on a man-of-war. This inconvenience is met in some cases by unkeying the stock and laying it along the shank, but this entails both trouble and delay. The only satisfactory solution of the difficulty is found in the stockless anchor and this is now universally used by men-of-war. Anchors, of whatever type, if designed to be carried on the bow, are fitted with a "balancing link" on the shank, and handled by a purchase or a pendant from a heavy iron davit, as shown in Plate **77**. This davit turns about a vertical axis, plumbing the proper point of the bill-board at one part of its train and swinging out well clear of the bow at another part. In men-of-war it is hinged to turn down flat upon the deck, out of the way of gun-fire.

At the davit head may be hooked either a heavy single block, swivelled and carrying a pendant, or the upper block of a heavy purchase, usually three-fold.

Where a pendant is used, it leads down to a block at the heel of the davit and then aft. In some cases a thimble is turned in the end and a deck tackle hooked to this, the fall going to a capstan or a winch; in others, the pendant is taken direct to the capstan, the length being such that there are several turns around the barrel when the pendant is hooked and set taut ready for surging chain.

If a pendant is used, it may be either chain or wire. The latter is to be preferred, and for several reasons. It works more smoothly on the barrel of the capstan, and is better adapted, by its elasticity, to stand the sudden jerks which are unavoidable in stowing anchors. For a given size of sheave, a stronger pendant may be used of wire than of chain; and a flaw in wire can be seen at once, whereas in chain it can never be detected until it gives away.



STOWING ANCHORS

Plate No. 78.

STOWING ANCHORS.

Plate No. 79.

"DELAWARE" PORT BOW SHOWING STOWAGE OF ANCHORS.

Shows club link and triplet as formerly used.

The anchor having been run up to the davit head, the davit is trained to plumb the bill-board, straps are put on the flukes and shank, and tackles hooked as necessary, leading fore and aft or athwartships, and the anchor is lowered slowly and landed in its place, where it is secured by the ring-stopper and shank-painter. In securing for sea, extra lashings are passed as may be necessary. In modern ships, the anchors almost invariably house in the hawse-pipes, thus doing away with all difficulties of handling and stowing.

FOUL ANCHOR.

The old-fashioned anchor often comes up with one or more turns of the cable around the stock, the shank, or the flukes.

The conditions here may vary so widely that only very general rules can be laid down for dealing with them. The anchor is usually hoisted to the davit-head and cleared by dipping the chain, unshackling if necessary. Slack chain is of course paid out, and the bight is hung by slip-ropes to take the weight. If the tackle cannot be hooked in its proper place, it must be hooked to a strap. Slew-ropes on the stock are helpful in clearing the turns.

If the anchor comes up crown first, a strap is used around the arms and shank, and the crown is run up to the davit head. It may be hung there by a hawser, the tackle shifted to the balancing link, and the anchor capsized by slacking the hawser and hauling on the tackle.

Sometimes a turn around the stock can be cleared by hooking the tackle with a turn in the opposite direction to that of the chain, while the anchor is at the hawse-pipe. As the chain is surged and the tackle run up, the anchor slews and the chain falls clear.

In all cases of unshackling, a hawser should be secured to the ring of the anchor, as something may give way when least expected. Much labor in lifting and dipping the chain may be saved by the use of two pendants, the anchor hanging by one, as usual, the bight of the chain by the other. The bight being thus held, the anchor is lowered, slewed clear of the cable, and again run up. By this method, *the anchor* is dipped, instead of the chain, and the heavy work of clearing is all done by the winch instead of by hand.

Whenever possible, the anchor should be landed in its place

and secured before the work of clearing begins. Where circumstances do not admit of this, it should at least be run well up to the bow and above the rail, where it can be reached conveniently. An anchor bar or small "crowbar" is very handy in opening out the parts of the chain when jammed one upon another.

Perhaps the most difficult case of fouling that can arise is one in which the chain is found hitched around the stock or the arm, with the hauling apart coming out from the inside of a round turn, and with this turn jambed hard upon it. Here it is particularly important to get the anchor close in to the forecastle. The parts may be pried apart a little at a time by means of a small, flat-pointed iron bar, and the hauling part dragged through the bight by a jigger on the end of the stock, the amount gained at each fleet of the jigger being lashed before the strap is shifted for a new pull. In this way, inch by inch, enough slack is accumulated on the bight to admit of lowering it over the end of the stock or fluke, where it will fall clear.

While modern swinging-fluke anchors are much less likely to foul than the old type, they occasionally give much trouble in this way and a ship whose anchors house in the hawse-pipes may be greatly embarrassed by the lack of facilities for lifting the anchor to a point where it can be hung securely and where the chain can be handled conveniently.

As a rule, the best that can be done in such a case is to hang the anchor by straps and stoppers, and send men over the bow to clear the chain as best they may, assisting them from the forecastle by lines and tackles to take the weight of the bight. A davit which can be shipped above the hawse-pipe, plumbing the anchor as it hangs outside, is very helpful here.

If it becomes necessary to unshackle the cable, ample precautions must of course be taken to secure the anchor.

ANCHORING BY THE STERN.

It is often convenient and sometimes necessary to anchor by the stern. For this an anchor of moderate size is usually sufficient, and it is an excellent plan to carry such an anchor at the stern ready for letting go in a hurry.

Battleships of the United States Navy now carry stern anchors of about 6000 pounds. If a shackle is kept at hand, and if a thimble is turned into the end of the best wire hawser, this hawser can be run aft and shackled up to the anchor and all made ready

for letting go in a very short time. The ability to anchor in this way is so valuable under many circumstances, that it is surprising how rarely it is thought of or prepared for. In coming to, in a narrow or crowded anchorage with a fair tide—where perhaps difficulties are found which had not been anticipated—it might be of the greatest possible value. So, too, in going alongside a dock or into a slip, with a fair wind or tide, as it is sometimes necessary to do, a stern anchor such as has been described (not a mere kedge) might make a perfectly simple situation out of one which would otherwise be very difficult.

In the event of stranding, such an anchor can be laid out very quickly, and while it probably would not serve to heave the ship off, it might very well hold her from driving farther on with a rising tide and at the same time prevent her from swinging around, broadside on, to the beach.

If it becomes necessary to use a *bower* anchor over the stern, the simplest way to deal with the situation is to ease the anchor down until it hangs outside the hawse-pipe with its ring just clear, at the same time making preparations for unshackling at the 5-fathom shackle, and holding the chain—outside of this shackle—by a good slip-stopper. Pass the end of the best wire line out through the stern chock, take it forward and shackle securely to the ring of the anchor. In this as in all other cases where the anchor is to be used without its own cable, it is very important to use a "weighing-line" and buoy-rope on the crown of the anchor. (Chapter X, Sec. 2.)

Let go when ready by knocking off the link of the slip-stopper.

If it is desired to ride by the bower cable rather than by the wire-line, pass the line forward from the stern-chock as before and stand by to shackle it to the chain when ready. Run in at slow speed to the point where the anchor is to be placed, keeping the ship under control; let go, and veer to 60 or 90 fathoms as desired, bringing-to with the shackle well inside. Pass the end of the wire line inside the hawse-pipe. Stopper the chain well, and bend on an easing-out line just forward of the shackle. Take the easing-out line to the capstan and take the strain on it. Shackle the wire line to the shackle of the chain. Unshackle the chain. Take the after end of the wire line to the after windlass. Ease out forward, heave in aft. Let the easing-out line go with the chain, standing clear of the end. Heave the line and cable in aft, and secure.

If it is desired to moor head and stern for experimental firing or any other purpose, steam ahead dead slow as soon as the cable is unshackled and everything is ready for easing away, and stand on to the point where the other bower is to be placed leaving the stern wire line slack, and being careful to keep it clear of the screws. When the second anchor is placed, heave in on the line aft, bringing the cable of the stern anchor in through the stern chock, and secure.

In this last described case it will be well to use full 90 fathoms on the stern anchor.

§ IV. RIDING AT SINGLE ANCHOR.

Vessels having windlasses of the type that has been described are not usually fitted with riding-bitts, the wildcat taking the place of these, and the chain being further secured for riding, by stoppers. The wildcat is *unlocked* from its driving head and held only by the brake, which should be lashed down. If it becomes necessary to veer, the stoppers are cast off, and the chain veered and controlled by the brake. If the wildcat were locked and the windlass held by the main pawls, it would be necessary to heave back, before veering, in order to release the pawls. In this way, moreover, the chain would be held rigidly upon the windlass, and the relief which might be given by the yielding of the friction brake under an excessive stress, would be sacrificed. In cases where such excessive stresses are to be anticipated, as for example when a vessel is *compelled* to ride to a short scope of cable in a seaway, it is a good plan to dispense with stoppers and controllers and to ride by the wildcat alone, with the brake set up fairly taut. The violent jerks upon the chain will cause the brake to *give* from time to time, and a little chain will be paid out, relieving the strain, and preventing the ship, it may be, from starting her anchor or parting her cable. *The brake, although lashed, must under these circumstances be attended by a careful man, and jammed down harder the instant the chain starts running out.*[1] Under these conditions, also, steam should be kept on the windlass, and when as much chain has been allowed to run out as it is thought well to give her, the brake is jammed down hard, the wildcat locked, and the

[1] The pressure which would give sufficient friction to hold the wildcat from starting would not suffice to keep it under control after it had once begun to turn. This is the difference between statical and moving friction.

cable shortened in, after which the wildcat is again unlocked and the ship left riding as before.

The advantages of a long scope of chain are universally recognized, but probably few seamen realize in just what ways such a scope contributes to the safety of the ship and the ease with which she rides.

Perhaps the most obvious gain is in the angle at which the pull of the cable comes upon the anchor. The longer the scope, the more nearly parallel to the bottom this pull will be; and the smaller, therefore, will be the tendency to break the anchor out. If the length and weight of the chain are such that any part of it rests upon the bottom, then the weight of that part is added to the weight of the anchor, and helps in this way to hold the ship. It has been found, however, that in the case of a ship riding to a moderate gale in ten fathoms of water and with 100 fathoms of chain, not a single link of the chain rests undisturbed upon the bottom. It is therefore clear that this point is not of as great importance as is commonly supposed. It is only in the two ways above described that a long scope is of value to a ship *which is pulling steadily at her cable;* but the moment she begins to sheer about, or to rise and fall in a seaway—alternately ranging up toward her anchor, then driving heavily back upon her cable—the value of a long scope makes itself felt in the elasticity of the bight, which prevents the rapidly varying tensions from being thrown upon the cable and the anchor in a succession of violent shocks. The cable never leads in a straight line from the hawse-pipe to the anchor, but dips downward in a curve, the degree of curvature depending upon the depth of water, the length and weight of the cable, and the tension to which it is subjected. With a long scope of chain, under a moderate tension, the curvature is very marked. If, now, a ship riding in this way begins to drive astern before a heavy squall, she must lift the bight of her cable as she moves; and the longer and heavier the bight, the more work will be involved in lifting it, the more slowly the ship will move astern, and the more gradually the tension on the anchor and the chain will reach its maximum. It is one of the commonplaces of mechanics that a force has far less destructive effect when exerted gradually, than when exerted suddenly; and all experience confirms this principle in its application to a vessel riding at anchor as above described.

It is a common rule to give, under ordinary circumstances, a

length of cable equal to seven times the depth of the water. This is perhaps enough for a ship riding steadily and without any great tension on her cable, but it should be promptly increased if for any reason she begins to jump or to sheer about; *for it is always easier to prevent an anchor from dragging than to make it hold after it has once begun to drag.*

A vessel at single anchor in a strong tide-way is likely to sheer considerably, bringing the current first on one side and then on the other, and driving across the stream until brought up by her chain, often with a violent shock. This may be prevented in a great measure by holding her with a steady sheer—preferably away from her anchor—as in Fig. 6, Plate 80. This is accomplished by putting the helm over as far as may be necessary, and keeping it there. The stern is driven over to one side and she is canted across the current and held there. She is thus in more "stable equilibrium" than when riding with the tide nearly or quite ahead; and while she puts a heavier tension on her cable, it is a *steady* tension, which, as already explained, is not a dangerous one.

A ship is never in greater danger of dragging her anchor or parting her cable than when driving down with a slack chain, broadside on, or partially so, to wind or tide. Such a situation may of necessity arise in anchoring, or may come about in sheering, as above described. It not infrequently happens in squally weather, where a ship swings in one direction during a lull, just in time to be caught by a strong squall on the beam and driven bodily off, to bring up, it may be, with the chain taut across the stem.[1]

In lying at an achorage where such situations may arise, the greatest watchfulness should be exercised, steam being kept on the steering engine, and a man at the wheel,[2] an ample scope of chain veered, and a second anchor ready for letting go at a moment's notice. The last-named precaution should in fact be always taken; that is to say, a second anchor should always be ready, even though there seems no chance of its being needed.

[1] A cable or a hawser is greatly weakened by a bend or "nip," such as will exist at the hawse-pipe if the cable leads off at a sharp angle from the pipe.

[2] If a ship parts her cable and starts unexpectedly on a cruise, she may be in a measure controlled by the helm if actually moving through the water, and so saved, perhaps, from going ashore or fouling other vessels, until she can be brought up by another anchor.

Evidently, the danger of dragging is greatly increased if the anchor is foul. It seems to be generally considered that when riding at single anchor, the question whether an anchor is clear or foul is altogether a matter of chance, with which nobody on board the ship has anything to do. This was not so in the old days of seamanship, when the art of "tending ship" was an important part of the seaman's profession. The change is probably due in a large measure to the fact that anchors are now rarely *buoyed*, because of the danger that the buoy-rope would foul the propeller. It is no doubt difficult to keep a ship clear of her anchor with no means of telling where the anchor lies; but something can be done by watchfulness and care, if only to coax the ship by the rudder to swing always to that side of her anchor which will keep the chain from taking a turn around the anchor; that is to say, if she has swung once to the eastward of her anchor, she should, if possible, be made to swing back on the same side.[1] If she swings to the westward, and if the anchor fails to turn in the ground, the chain takes half a turn around any part of the anchor which may be projecting.

Under conditions such that the anchor may be expected to foul, it is a good rule to "sight" it frequently; and indeed this is advisable under any conditions when a ship remains at single anchor for a long time. It is especially important if, after lying for some time under circumstances which make it probable that the anchor may be foul, bad weather is found to be approaching.

In many harbors, a swell sets in on the beam of vessels riding to the wind, causing them to roll incessantly. In such cases, a stream anchor planted off the bow, with a line from the quarter, admits of springing around, head to the swell. In the tropics, a similar plan adds much to the coolness of the ship by bringing the wind abeam.

When anchoring in a narrow river or harbor where there is little room for turning and where occasion may arise for leaving hurriedly, it is well to keep a hawser triced up along the outside from the warping chock on the quarter to the hawse, ready for clapping on the chain. If an emergency arises while the ship is heading in, the spring is bent to the cable, and the cable un-

[1] The log should show the heading of the ship from hour tc hour, in port as well as at sea, and a note should be made, each time she swings, of the direction in which her head changes.

shackled. The ship then swings, the line is buoyed and cast off, and the ship stands out.

A man-of-war anticipating an engagement at anchor—a situation not often to be expected in modern warfare—should always have springs in readiness, leading from each quarter to the anchor, or, better, to kedges planted off the bow. The familiar story of the Saratoga at the battle of Lake Champlain illustrates this point impressively as a matter of both seamanship and warfare.

In preparing for action, she planted a kedge off each bow, with a line leading to the quarter, and hung a stream anchor over the stern. At a critical period of the engagement, all the guns of her engaged broadside having been disabled, the stream anchor was let go, with a line from its ring to the port bow, and the bower cable cut. The stern was hauled over to the kedge on the starboard hand, and the line from the other kedge dipped and brought in on the starboard quarter. (Figs 1 and 2, Plate 80.) With this line from the starboard quarter and the line from the port bow to the stream anchor, she was sprung entirely around, bringing the new broadside to bear. This manoeuvre decided the engagement.

It is always advisable to keep a shackle where it can be gotten at conveniently for slipping suddenly if an emergency arises, and to be sure that the pins can be driven out without difficulty. Tools for unshackling should be kept in a convenient place and never removed. A buoy and a buoy-rope at hand complete the preparations for slipping at short notice. In an exposed anchorage, subject to sudden gales, these precautions are of course especially important.

If, when lying at anchor in a tide-way, a vessel or other danger is seen drifting down upon you, you may, by giving the ship a cant with the helm, bringing the current on the bow, and veering away roundly, sheer well over across the tide and probably clear of danger.

If an anchor is known to have dragged, in a clayey bottom, it should be picked up as quickly as possible; for it is certain to be "shod," and to have lost much of its proper holding power. In letting go where the bottom is of this kind, it is important to give a good scope in the very beginning, to prevent even the little dragging that is commonly to be expected as the anchor digs down to gets its hold.

In riding out a gale, it may often be necessary to let go a second anchor, but there can be no question that where unlimited space is available, a ship is safer and easier with a single anchor

and a long scope of chain; and by a "long scope" is not meant 45 or 60 fathoms, but twice that length, or even more. Two cables will hold a ship longer if bent together and veered out to the double length on a single anchor, than if used separately, each with its own anchor down. It must not be overlooked, however, that a defective link or shackle may result in disaster where a single cable is in use; and this may make it wise, apart from other considerations, to let go a second anchor in cases where no chances can be taken. Some seamen veer to a long scope and drop a second anchor under the forefoot, leaving the brake fairly slack. If the riding-chain parts or the anchor drags, the slack chain on the other anchor will run out, giving warning of the danger and affording a means of bringing the ship up without the delay necessary for letting go the second anchor. If the ship swings, the anchor with the short scope of chain can be hove up before the chains foul.

When the conditions are such that there is a possibility of starting the anchor, a lookout should be kept which will insure instant notice if she begins to drag. The *drift lead* is useful, though not always to be trusted. This is a heavy lead, kept on the bottom, with its line made fast to some place convenient for observation and left hanging with considerable slack. If the ship drags, the line tautens and tends ahead.

So long as a ship is fairly steady, a drift lead will usually give notice in case of dragging, but if she sheers about considerably, it cannot be relied upon. The farther forward it is used the better, as the bow moves much less than the stern in sheering.

Good *bearings* of objects on shore are more reliable than the drift lead, and a *range* is best of all; but these, also, are less trustworthy when the ship is sheering about than when she is steady; for a range will open out when the ship swings, and may seem to indicate that she is dragging. Its indications may be checked by watching the heading.

Where no range can be picked out on shore, two single marks *on opposite sides of the ship* answer well, if the observer takes his stand at some spot to which he can return from time to time, and notes a point on the ship itself in line with each of the points on shore.

Suppose, for example, that from a certain point on the bridge or deck, a shore mark to starboard is in range with a swifter of the rigging, an awning stanchion, or some other conspicuous point of the ship; while another object

to port is similarly in line with something on the ship along the port side. As the ship swings, one object will draw ahead and the other will draw aft. If she drags, both will draw ahead.

If the compass is conveniently placed for observation, a single bearing upon an object near the beam and at a reasonable distance, will give all that is needed, although here, also, allowance must be made for swinging.

It sometimes happens that the ship can be felt to start, by a slight jar due to the sudden slacking of the chain as the anchor lets go its hold; and if she drags for any distance, there will almost always be a tremor in the chain, perfectly perceptible to the hand, due to the variation in resistance which the anchor meets as it moves along the bottom. This is a good thing to know in cases where no other indications are available.

§ V. MOORING

A vessel is moored when she has two anchors down at a considerable distance apart and with such a scope of chain on each that she is held with her bow approximately stationary on the line between them.

A vessel so placed may head in any direction, but will swing, roughly speaking, about her own stem as a pivot; the amount by which she deviates from this depending upon the tautness with which she is moored.

The advantages of mooring are that a vessel takes up comparatively little space in swinging and that she cannot foul her anchors by dragging the bight of the chain over them. The disadvantages are that she must often ride to a span, and must either be hampered by a mooring swivel or have constant difficulty and annoyance from a foul hawse. So long as she rides to a wind or current setting along the line on which her anchors are laid out, she is practically at single anchor, though she may of course drop down beyond the leeward anchor and hold on with both cables taut ahead. But if a gale comes up from any direction athwart the line between her anchors, she rides to a span, and the tension on the cables will be altogether out of proportion to that utilized in holding the ship. In Fig. 3, Plate 80, suppose A riding to a gale from the east, her anchors being laid out on a north and south line and the cables making an angle of 10° with this line. If the force acting on the

ship along A C is 20 tons, the tension on each cable will be 57½ tons.

Thus, under conditions such that a single anchor and cable ahead would have to bear a tension of only 20 tons, two cables in a span are subject to a total tension of 115 tons. If the angle N A S is more obtuse, the tension is increased. If the ship veers and drops to leeward, bringing the cables more nearly ahead, the demand upon them becomes less; and when the angle N S A is 30°, the two cables together have exactly the holding power that one would have if laid out singly ahead (Fig. 4, Plate 80). As the ship continues to drop down, the cables act more and more efficiently, and if a long enough scope is given, their holding power becomes nearly double that of either one alone.

It will be clear from this that in riding out a gale with open hawse it is even more important than with a single anchor, to veer as long a scope as may be possible. If such a situation is anticipated at the time of mooring, the anchors should be laid out closer together than they otherwise would be; indeed, there is always an advantage in mooring with rather a short scope on each chain (provided such a length is used that she cannot swing over her anchors); for if a gale comes up along the line of the anchors it is easy to veer the riding cable and drop down to leeward, bringing both anchors ahead, where they will act better the closer they are together; and in riding with open hawse, the same point gives the advantages which has been illustrated above.

If a mooring swivel is to be used, these remarks as to the advantage of a short scope do not apply, since it is impracticable to veer away on both cables as above recommended.

There are many situations in crowded harbors where mooring is a necessity, especially if a number of ships are together in squadron. When this is not actually necessary, it is safer and more convenient and therefore more seamanlike, to use one anchor, with a good scope of chain which can be practically indefinitely increased if necessity arises, and with the second anchor ready to be let go on the line where it will be most effective.

TO MOOR.

In mooring in a tide-way, where it is desired to lay out the anchors along the line of the tidal current, as is usually done, the simplest way of maneuvring is to head up against the current,

stopping at the point where the "weather" anchor is to be planted and letting go as the ship begins to gather sternboard, backing the engines if the tide is not strong enough to insure laying out the chain properly. It is better not to use the engines unless necessary, because to do so is almost certain to cut the ship across the current and off the line on which the anchor should be laid out.

The weather chain is veered away as the ship drops down, care being taken to lay it out fairly taut, until the point is reached where the leeward anchor is to be placed. If we are to moor with 45 fathoms on each chain, we must veer to a little less than 90 fathoms before letting go the second anchor, keeping the 90-fathom shackle inside the hawse by an amount which will depend very largely upon the method which is to be used for putting on the swivel. The farther inside the hawse we leave the shackle, the slacker will be the moor, and as the putting on of the swivel in itself slacks the cables materially, care should be taken not to keep the shackle farther inside than is absolutely necessary. No rule can be given here, but experience has indicated that if the first chain is laid out properly, and if the 90-fathom shackle is held about 2 fathoms inside the hawse (counting from the outboard face of the pipe), when the second anchor is let go, the resulting moor will be about right, with most types of ships and in ordinary depths of water.

A FLYING MOOR.

In making a flying moor, the first anchor is let go with the ship going ahead at considerable speed, and the first chain laid out as she ranges ahead. This calls for good judgment with regard to the initial speed, and with regard also to the use of the chain and the engines for checking the speed.

It has been already stated in connection with "Anchoring" that almost any ship, running at a speed of from 4 to 5 knots, with steam available for 12 knots, and backing with full power as the anchor is let go, can be brought up at 45 fathoms without undue strain. Since for mooring we wish to run out double this length of chain (assuming that we want 45 fathoms on each anchor), we may back with half power in the beginning and be governed by conditions as to using more power or less, as the chain runs out. It will probably be found under average con-

ditions that by continuing to back with half power and gradually snubbing the chain toward the end of its scope (never in the beginning) she can be brought up with about 90 fathoms.

It is very important not to begin to snub her with the chain until at least 30 or 40 fathoms has been laid out, as to do so is almost certain to start the anchor or part the chain, or at least to strain it injuriously. After laying out a good scope—45 fathoms or more—the danger of this is greatly reduced and a little snubbing helps to lay the chain out taut.

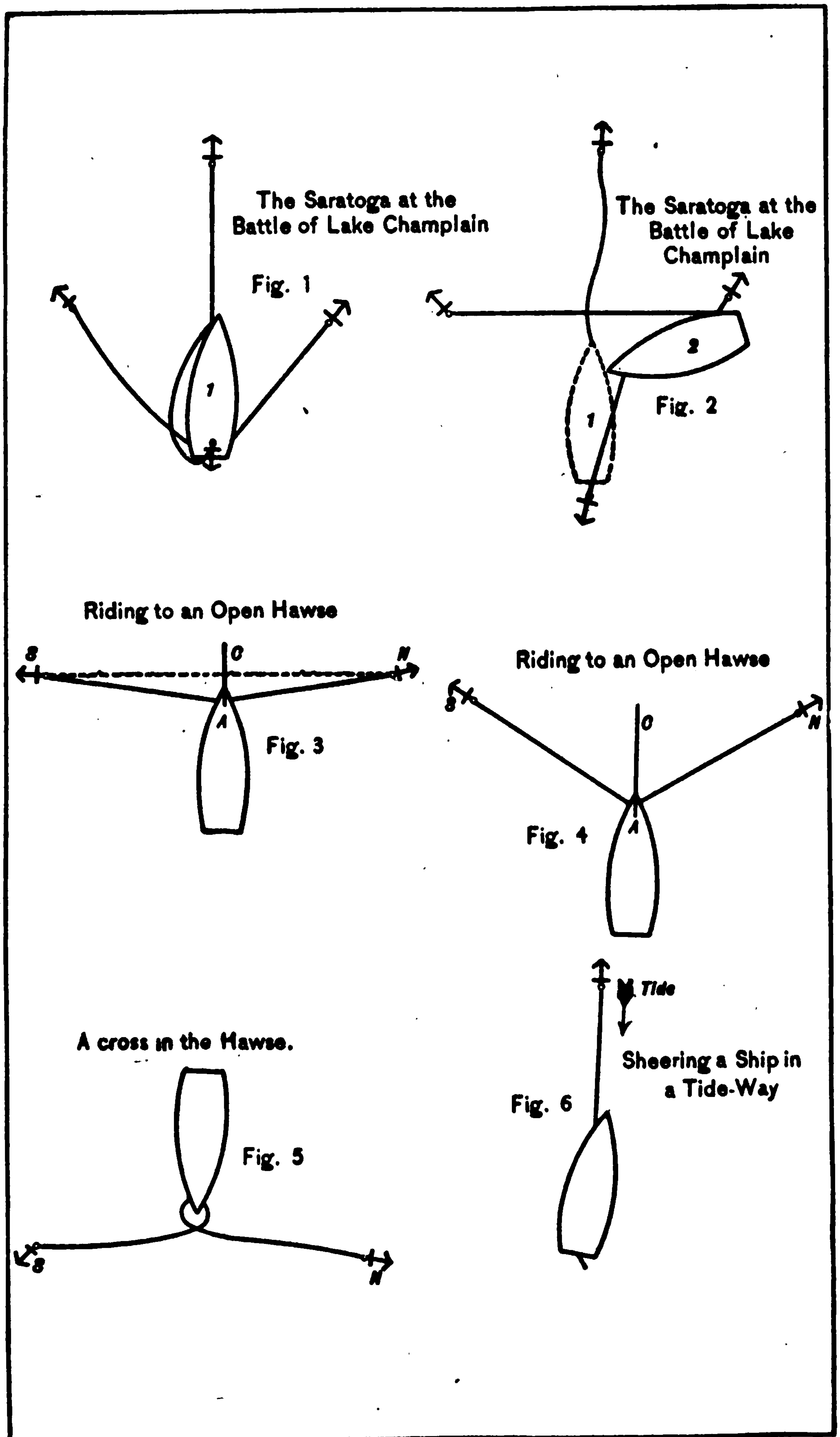
As a very rough rule, then, to be modified by actual experience for each ship, we may say, let go the first anchor at a speed of from 4 to 5 knots and at once back the engines at half speed, letting the chain run out freely. After about 45 fathoms has gone out, snub her from time to time with the chain, but without putting a dangerous strain on it, and regulate the engines (stopping, backing faster or slower, or if need be going slow ahead) so as to be sure of *bringing her up* in the end (the 90-fathom shackle inside) *with a moderately taut chain.* Then let go the second anchor, heave in on the first chain, veer away on the second, and drop *down* to a point midway between the two anchors, when both shackles should be somewhat inside the hawse, giving drift enough for working the chain as described below for clearing hawse or for putting on the swivel.

Note the remarks upon the method of governing speed in approaching an anchorage in the section of this chapter on "Anchoring."

CLEAR AND FOUL HAWSE.

A vessel moored has a "clear hawse" when her cables lead off on their respective sides, clear of each other. She has a "foul hawse" when they are crossed or otherwise foul of each other.

In Fig. 3, Plate **80**, A rides with an "open hawse," heading west, her starboard anchor being to the north and port anchor to the south. She may swing through eight points to either side without crossing her cables; and so long as she swings backward and forward, *her stern going each time to the eastward,* the hawse will remain clear. The moment her stern swings to the westward of the north and south line, however, the chains begin to cross. In Fig. 5, she has swung through half a circle from an open hawse, and has now a "cross" in the hawse. If before swinging to the westward she was riding to the starboard anchor,



ANCHORING WITH A SPRING, MOORING, ETC

the starboard chain will now be on top; and to swing clear, her stern should go back to starboard. It is a rule easily remembered, that to clear the hawse by swinging, the stern must always go toward the side of the cable that is on top.

If, having swung in such a way as to put a cross in the hawse, she continues swinging in the same direction, she puts in, successively, an "elbow," a "round turn," a "round turn and an elbow," and so on.

It is evident that a foul hawse will be cleared if the ship can be made to swing back in the direction opposite to that in which she has swung in fouling; and with a little watchfulness this may often be done, by giving her a cant with the rudder on the last of a tide. The hawse may often be kept clear in this way when it would otherwise foul; and the situations are frequent when a cross or an elbow can be swung out. In the case of anything more than this, it is better to proceed at once to "clear hawse," as follows:

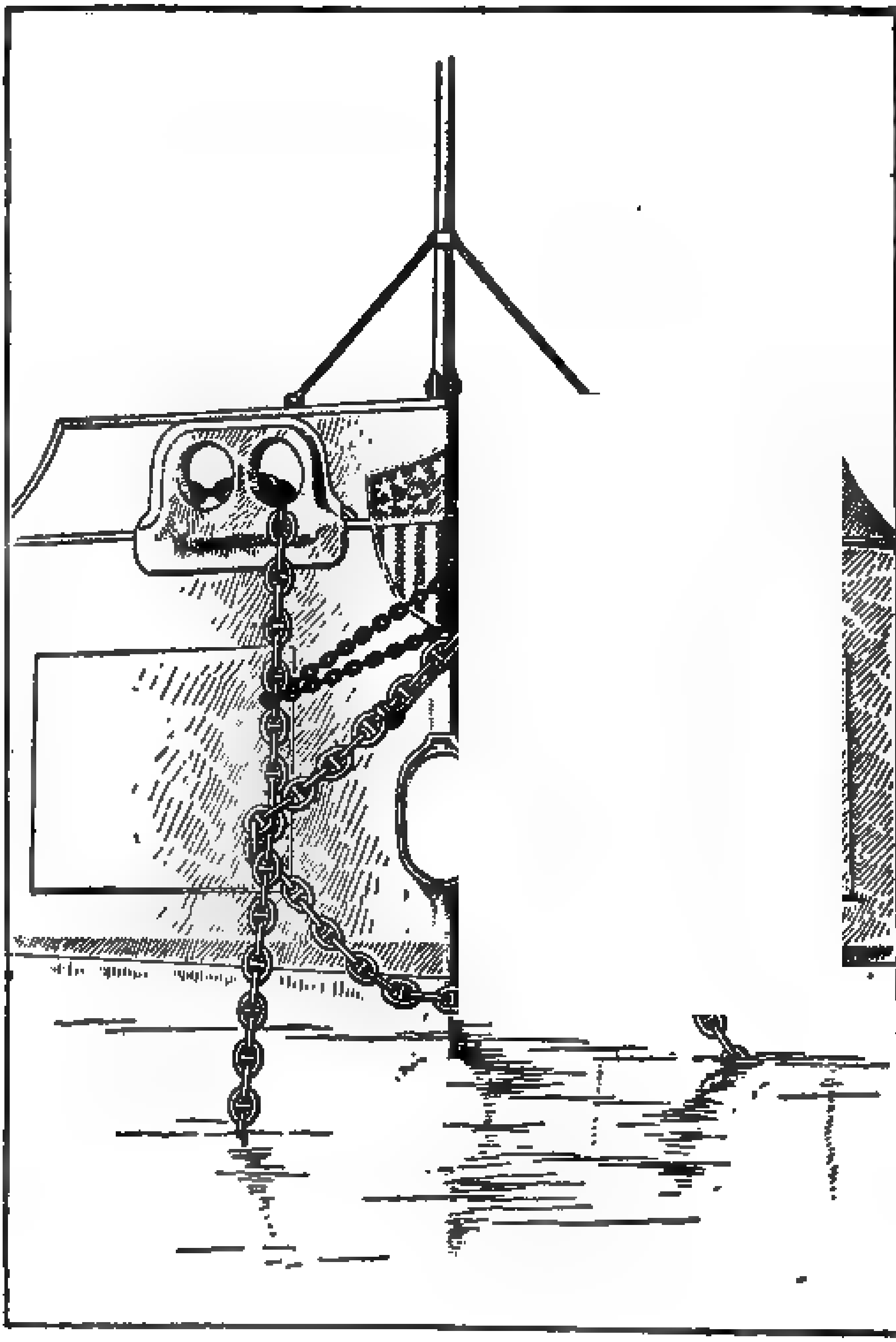
TO CLEAR HAWSE (Plates 81 and 82).

This should be done if possible at slack water, preferably just after the ship has finished swinging and before the new tide begins to run strongly. The lee chain is always the one to be unshackled, never the weather one. The clear-hawse gear consists of:

1. The *clear-hawse pendant,* of open-link chain, 6 fathoms in length and of metal one-half the diameter of the chain with which it is to be used. The outer end of the chain is fitted with a *slip,* or pelican hook. The inner end is fitted with a shackle having a round bolt and a solid thimble into which is spliced a tail of wire-rope about 30 fathoms long.

2. The *dip-rope,* of open-link chain or, still better, of 3-inch circumference wire, about 6 fathoms in length, the outer end of which is fitted with an eye carrying a shackle large enough to engage a link of the cable. To the other end is fitted a tail of 7-inch manila about 30 fathoms in length. The outer end, of chain or wire, takes the chafe in the hawse-pipe, and the manila tail goes to the wild-cat, where it is found to work more smoothly than if made of wire as was formerly the practice.

3. A *hawser* to be bent to the chain above or below the slip-hook of the clear-hawse pendant, as a preventer, in the event of parting the pendant.



Clearing Hawse.

4. A *line* on the chain from the inside, for easing out after unshackling. This is not always used, but is convenient and may be necessary with a heavy chain.

5. *Deck tackles, hook ropes, chain hooks, straps, rope* for lashing, *tools* for unshackling and shackling, etc.

If the turns in the cables are below water, they must be brought above by heaving in the riding cable. If they are inclined to slip down—as may be the case if the chains are slack—they must be lashed; and many officers prefer to lash them in all cases. There is no question that this reduces the chance of accident, both to the cables, and, what is more important, to the men working them.

A ship with a ram-bow, having a foul hawse, will sometimes forge ahead, bringing the turns below the ram so that the cables lead up and down and seem to be clear; and in any type of ship, if the moor is rather slack, there are chances that the hawse will look clear when it is in fact very badly foul. If proper entry has been made in the log of the swinging of the ship, this should not lead to misunderstanding, but it may cause considerable difficulty. If steam is available, a few turns of the screw astern will bring the turns up where they can be gotten at. In other cases, it will usually suffice to heave in on the riding cable and veer on the lee one. Much depends upon the shape of the ram and the position of the hawse-pipes, but there is always some way of handling the chains to meet this and other difficulties which arise in working ground-tackle.

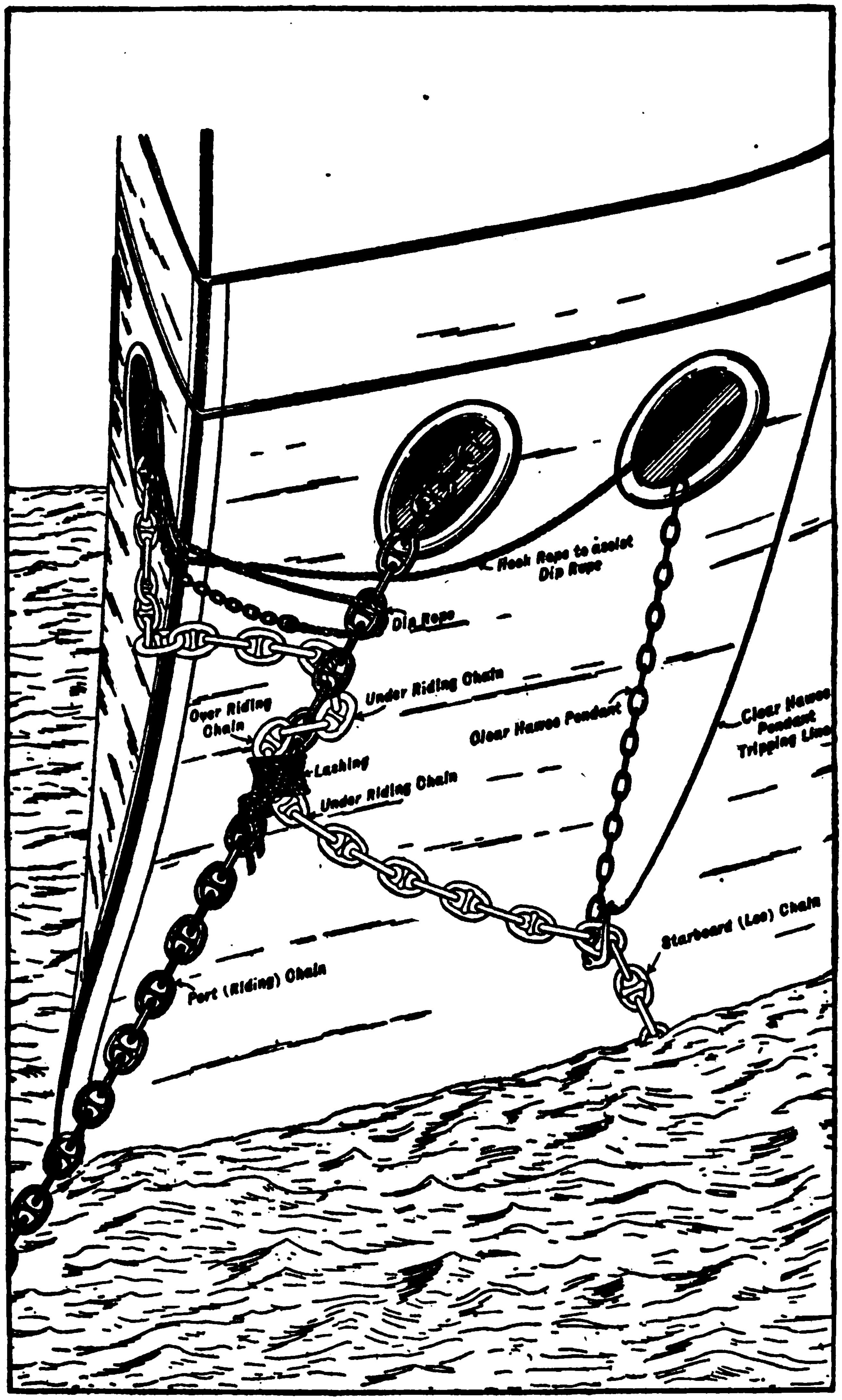
The turns being above water, the clear-hawse pendant is passed out the sheet hawse-pipe or through a warping chock, and secured to the lee cable below the turns, after which it is taken to the capstan or a winch, hove taut and secured.

In a ship with a ram-bow, the turns usually come up on one side of the ram;—the side of the riding cable (Plate 82). In this case, the clear-hawse pendant, although still used on the lee cable, is passed out on the side of the *riding* cable.

The preventer hawser is also passed out, bent to the cable, hauled taut and secured.[1] If the turns are to be lashed, this is done now.

The dip-rope is passed out of the hawse-pipe alongside the lee

[1] This supposes that the preventer hawser is to *hold* the chain in case the pendant fails. If it is intended only for *weighing* the chain, it is left slack but the end is made fast. The latter is the better plan.



Note:—The starboard anchor lies to starboard of the ship.

CLEARING HAWSE.
BOTH CHAINS ON WEATHER SIDE OF RAM.

cable, taken around the riding cable in a direction opposite that of the turns to be taken out, and brought back inside, where it is secured to the cable forward of the shackle; preferably to the end link.

The dip-rope is often made fast to the second or third link forward of the shackle, to leave slack on the end for convenience in shackling and unshackling; but this makes trouble when it comes to hauling the end in through the hawse-pipe; and the better way is to bend it to the end. Then, after the turns have been cleared and the end hauled in again ready for shackling, the chain is secured with a stopper, leaving plenty of slack end for working, and the dip-rope is cast off altogether.

The lee chain is secured by a stopper and the end of the "easing-out" rope made fast a few links forward of the shackle and stopped to the end link. The cable is then slacked up and unshackled, the controller released, and the chain hauled out by the dip-rope, the end of which is taken to a winch.

The lead of the dip-rope is unfavorable for hauling out, and with a heavy chain it may be necessary to lead a line out on the side of the riding cable, and take it in through the lee hawse-pipe to assist in hauling out the end of the cable (Plate 82). Chain-hooks, hook-ropes, etc., are used inside for lighting the chain forward.

The dip-rope, assisted as before described if necessary, takes out the turns and brings the end inside the hawse-pipe, where it is secured by a stopper and shackled. The chain (lee) is then hove moderately taut, the controller released, the preventer hawser cast off, and the clear-hawse pendant tripped by means of the lanyard on the link.

On large ships the chains usually cross below the water-line, even although they are hove taut; and to put on the heavy clear hawse-pendant and secure a preventer hawser over the bow is very difficult. This difficulty is overcome by securing the lee chain *on deck,* by stoppers, rousing out sufficient chain to reach around the riding chain as many times as there are turns in the foul hawse and back on deck, and unshackling. The dip-rope is rove around the riding chain in the proper direction for clearing the hawse, hooked to the end link of the outboard part of the lee chain and hauled taut. An easing-off line is secured to the bight to be eased out, and a heavy hook-rope and a line for hanging the bight are put over the bow. When the lee chain is eased out, it is lighted around the riding chain by means of the hook-rope and hanging line, while at the same time the

dip-rope takes in the slack. When enough slack is on deck to shackle up, the lee chain is again connected, the clearing gear gotten out of the way, and the lee chain hove in by the windlass until it is clear of the riding chain.

In small ships the hawse is often cleared from a boat under the bow, the shackle being veered out into the boat and there unshackled, dipped, and shackled again. It is well in this case to lash the turns and to take the weight of the chain by slip-ropes from the bowsprit or forecastle.

Some ships have a light davit which can be stepped at the stem when needed for working chains. This is a great convenience and in many ships almost a necessity.

A *cross* in the hawse cannot be cleared, as the chains lead off on the wrong sides, the starboard anchor being on the port hand and the port anchor on the starboard hand. The chains may be unshackled and shifted, the former starboard chain becoming the port one and the port becoming the starboard, provided this does not interfere with stowing the anchors on their bill-boards.

It is a common practice for ships whose anchors house in the hawse-pipes to carry both bowers on the same side. This obviates many of the difficulties and inconveniences connected with mooring, clearing hawse, etc.

If it becomes necessary to weigh when there is a cross, the anchor belonging to the cable ***underneath*** must be picked up first; as the upper one, if picked up, would foul the other chain.

It is clear from what has been said about the hawse, that it is not a matter of indifference in what way the anchors are laid out. In Fig. 3, Plate **80**, for example, they are properly placed provided the probability is that the wind, in the event of bad weather, will haul to the westward, thus keeping the hawse open. If the wind is more likely to haul the other way, the starboard anchor should be to the southward.

THE MOORING SWIVEL.

A vessel moored may avoid the necessity for clearing hawse by using a mooring swivel (Fig. 2, Plate **84**). This is much like an ordinary swivel, but larger and heavier and with two links and shackles attached to each of its parts. It is shackled upon the cables just forward of the stem in such a way that the parts

of the cables leading from the hawse-pipes are connected to the inner shackles, and the parts leading off to the anchors, to the outer shackles. As the ship swings, the swivel turns and keeps the cable clear. It should be put on with the cup up.

There are some disadvantages connected with the use of the swivel. It is very inconvenient in veering, and still more so in weighing, as it must be taken off before either anchor can be picked up. In spite of these disadvantages, it is almost invariably used by men-of-war.

In view of the difficulty in veering where the swivel is used, a vessel proposing to use it should moor with a good scope on each chain in the beginning. The conditions here are quite different from those where a ship is moored without a swivel and free to veer at any moment. Under the last-named conditions, as has been explained, there is a certain advantage in having the anchors not too far apart, but this reasoning does not apply if the swivel is to be used.

As both clearing hawse and putting on the mooring swivel involve unshackling, the scope on each cable in mooring must be made such as will bring a shackle near the hawse. Where the cables are made up of 15 fathom shots, we may use 30, 45, 60 or 75 fathoms on each. In the United States Navy, the latest cables issued to ships have no shackle between five fathoms and forty-five, so that nothing less than forty-five fathoms can be used on either cable (in mooring).

It is usual in laying out the cables to bring the shackles a little inside, but not so far as in cases where the swivel is not to be used. This is because the insertion of the swivel slacks the cables considerably, and with a slack moor there is danger that the swivel will not turn. The exact position for the shackles will depend upon the depth of water and the construction of the ship.

It is a common and convenient practice in using the swivel to connect only one cable from the hawse, the end of the other being kept inboard. This does not involve any loss of holding power, for the reason that, so long as the ship rides to one cable only, the single part leading inboard is as strong as that from the anchor; and when she rides with an open hawse, the parts beyond the swivel form a span, which, as has been shown, has actually less holding power than a single part acting along the line on which the ship is pulling.

Some ships shackle both chains from inboard to the swivel,

and to prevent them from sawing across the stem leave one of them slack and dip the bight of it down under the forefoot. They thus ride to a single part, but have the other to rely upon in case of accident and can heave the swivel up to either hawse-pipe for taking it off.

PUTTING THE SWIVEL ON.

It was formerly the rule to put the swivel on the lee chain first, then to wait for the ship to swing before putting it on the other one. This is still the rule in cases where the swivel is put on *outside the hawse*. But many modern ships have hawse-pipes large enough to let the swivel and several parts of chain pass freely; and in such ships it is put on inside, *and on the riding cable first*, the lee cable being afterward secured by the clear-hawse pendant as in clearing hawse, unshackled, and the end coming from the anchor hauled around the stem and inside the riding hawse-pipe, where it is shackled in its place on the swivel.

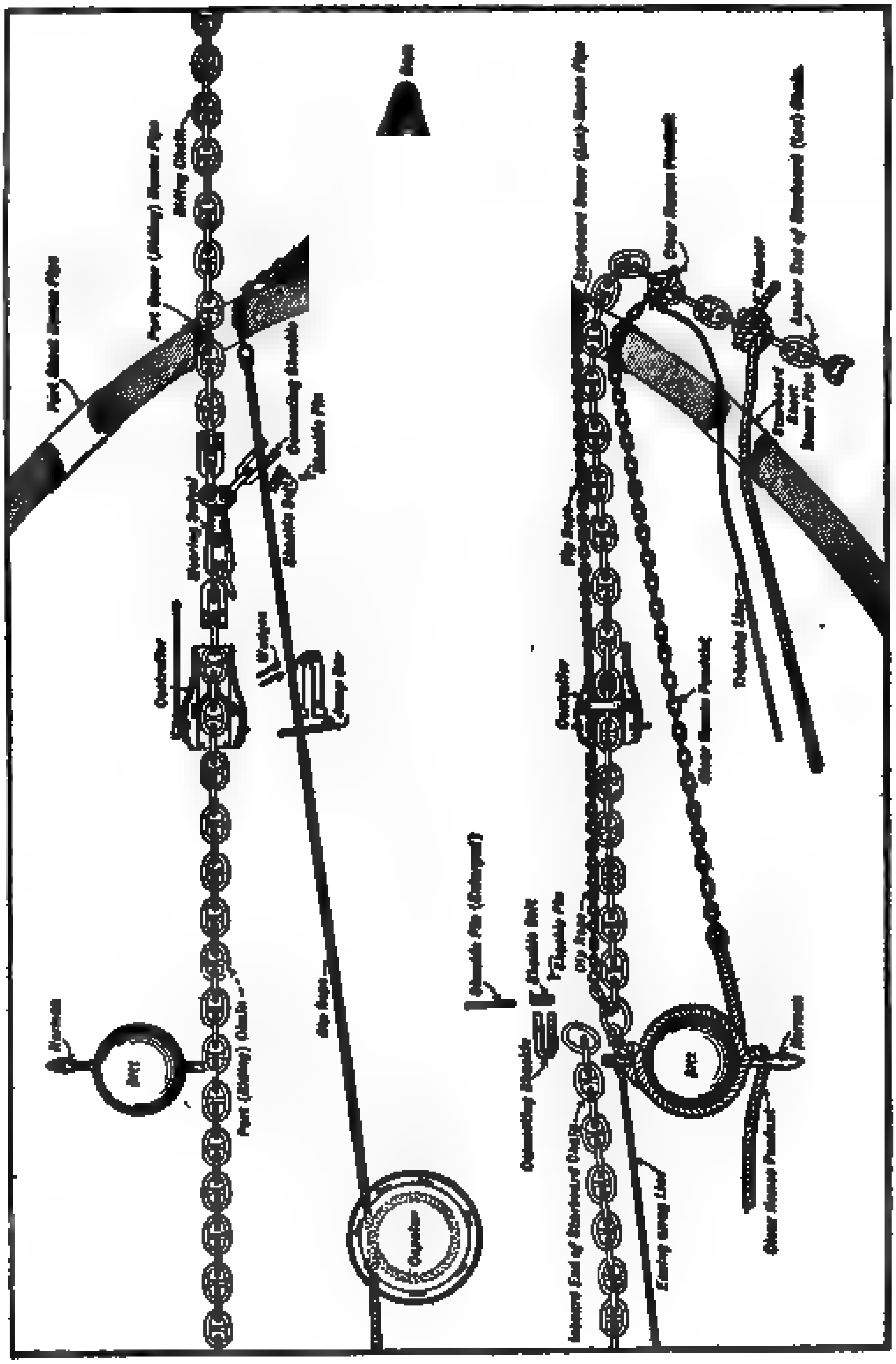
First Method. The details of this method are shown in Plate 83.

The first thing to be done is to heave in on the *riding cable* until the shackle is inside and at a convenient point for working, when the chain is secured by one or more stoppers, all of course forward of the shackle. The riding cable is then slacked abaft the stoppers and unshackled, and the swivel shackled in place. In the meantime, the clear-hawse pendant has been put on the lee cable and hove taut, and a preventer hawser made fast, as in clearing hawse. The dip-rope is passed out through the riding hawse pipe, brought in the lee hawse pipe, and made fast to the lee cable just forward of the shackle.

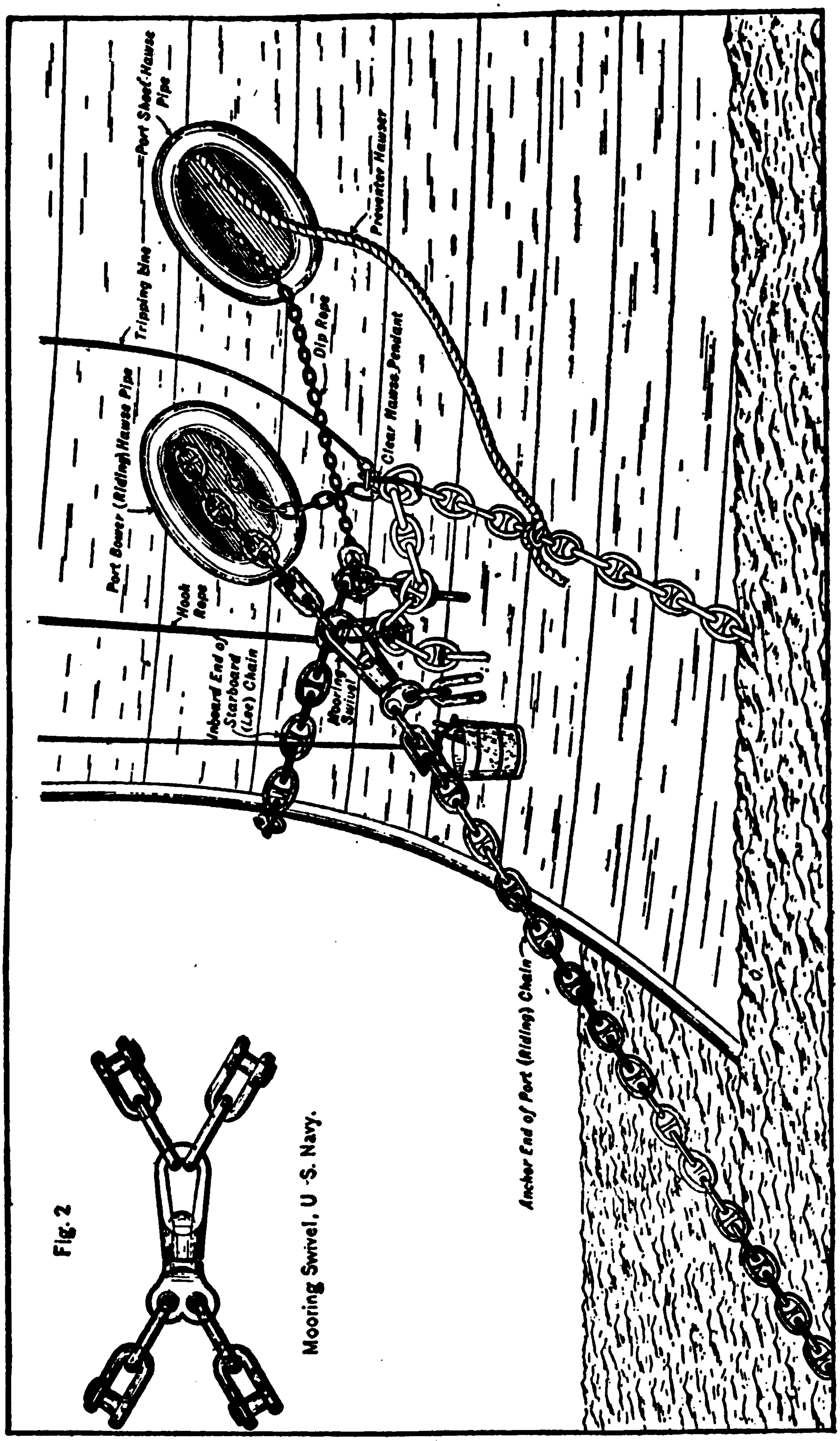
The lee chain is next unshackled inside, and the end of it leading from the anchor is hauled out by the dip-rope, across the stem and in through the riding hawse-pipe, where it is shackled to the *forward* end of the mooring swivel. The riding chain is then veered away until the swivel is outside.

If, now, it is proposed to connect the other part of the lee cable (from inboard), this part is hauled out by the dip-rope and shackled in its proper place on the swivel.

Second Method. If the hawse-pipe is large enough to take the swivel, but not large enough to take the two cables alongside each other, the swivel is put on the riding cable as just described and



CONNECTING SWIVEL UP INSIDE HAWSE.



PUTTING ON OR TAKING OFF SWIVEL OUTSIDE.

then veered outside, before connecting up the anchor end of the lee cable; the clear-hawse pendant, dip-rope, etc., being used as before, except that the dip-rope in this case would be rove a little differently; perhaps through a link of the riding cable just below the swivel, or even through the swivel itself; the idea being to get the end of the chain to the point where it is wanted, by whatever means is most convenient (Plate 84). In this case also it is necessary to bend the dip-rope to the lee cable several links forward of the end, to give the slack required for shackling. The men handling the chain work either in a boat under the bow or on a stage slung over from the forecastle, such lifting as is required being done by slip-ropes, and all shackles, mauls, etc., being slung by lines to avoid danger of their being lost. This method gives a tauter moor than either of the methods, already described, in which both chains are shackled to the swivel inside the hawse.

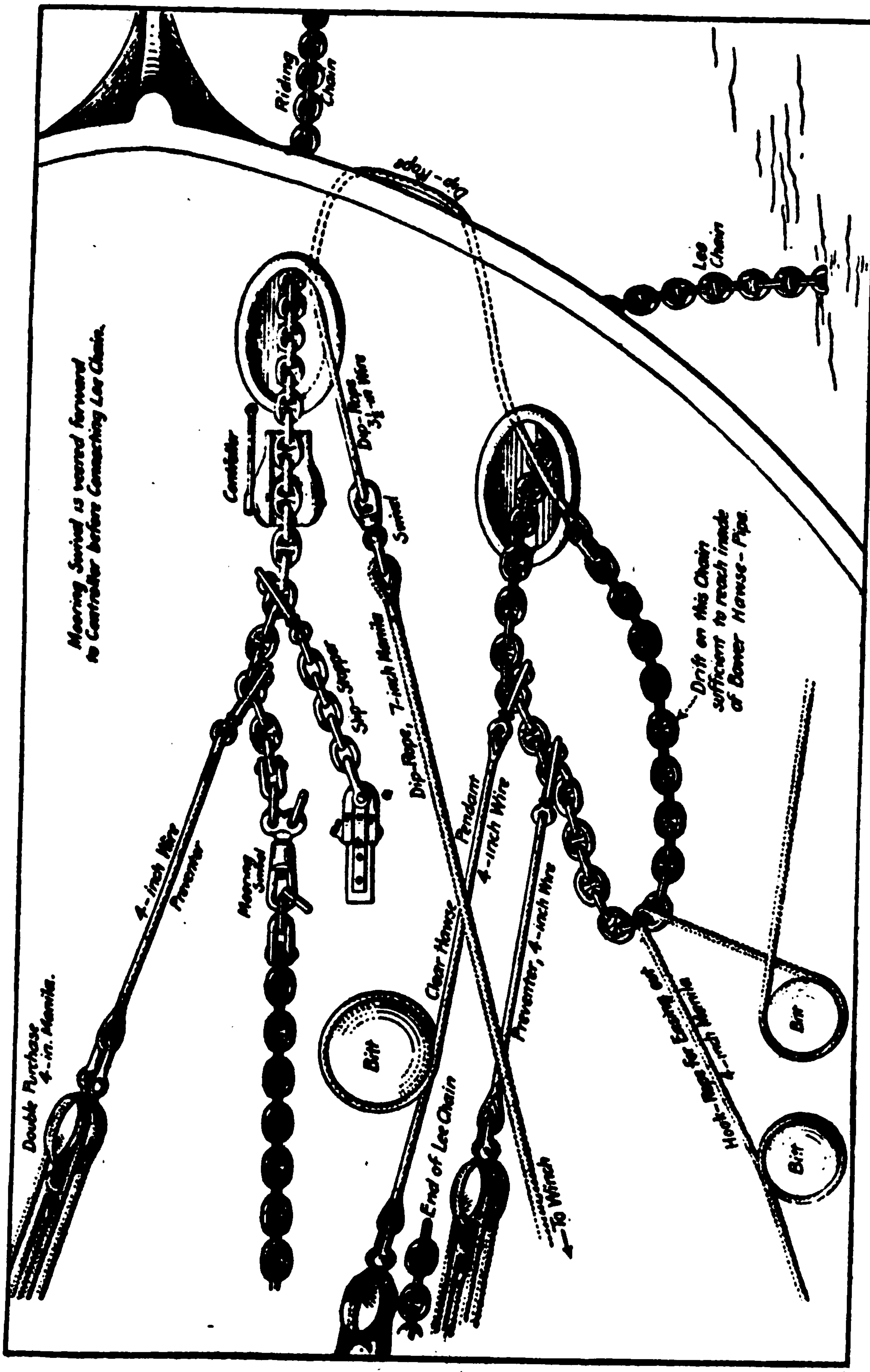
Third Method.[1] Plate 85. This resembles the First Method above, but with several important points of difference, the most important being the following: all gear is kept inside and no one is sent over the bow at any stage of the operation; wire-rope pendants are substituted for chain as being more reliable, and two-fold purchases are used with the pendants, giving a gain not only in power but in smoothness of working; work proceeds on both chains simultaneously, giving a marked gain in time; the chains are under perfect control at all times, all violent "surging" being avoided.

The gear consists of: a *clear-hawse pendant,* two *preventers,* a *dip-rope,* an *easing-away line,* and *deck-stoppers* as required.

The clear-hawse pendant and both preventers are of 3½-inch wire, with a pelican-hook at one end for engaging the chain and an eye in the other end, to which is shackled the block of a heavy two-fold purchase. The dip-rope is in two parts connected by a swivel to prevent the accumulation of turns as the chain is hauled around, the outer part, of 3-inch flexible wire, about seven fathoms in length, shackling to the lee chain; the inner part, of 7-inch manila, leading to the winch. The size of gear required will of course vary for different ships. The dimensions given are suitable for ground-tackle such as is used by the "Rhode Island" class of battleships.

[1] This method was worked out by chief boatswain J. P. O'Neill, U. S. Navy, and used with excellent results on the U. S. S. "Rhode Island."

Plate No. 85.



PUTTING ON SWIVEL—THIRD METHOD.

The dip-rope is rove off as the anchorage is approached, out through the forward hawse-pipe and in through the after one (assuming that the after anchor is to be the first let go). The dip-rope is made fast at some convenient place on deck and hauled taut to keep it clear as the chains run out when the anchors are let go.

All gear is broken out and each part is placed as nearly as practicable where it is to be used; the blocks of the clear-hawse pendant and the two preventers being hooked to their respective pad-eyes or straps, and the falls overhauled to the proper length, but all placed carefully where they will be clear of the cables. If a bitt is conveniently placed for the purpose, it is well to take a turn around it with the clear-hawse pendant, as shown.

One great advantage of this method is that both cables may be handled at practically the same time; and all preparations, including the assignment of men to the various duties, should be planned with this in mind.

The lee anchor having been let go, the riding chain is hove in until the shackle is at the proper point, which on the "Rhode Island" is found to be just forward of the bitt.

Both cables are now secured as shown in the plate; the riding cable by the deck-stopper and the preventer, and the lee one by the clear-hawse pendant and preventer, the purchases of the clear-hawse pendant and both preventers being hauled taut and belayed.

In securing the riding chain, about three links are left between the deck-stopper and the preventer. The point for the clear-hawse pendant and preventer on the lee chain is determined by the consideration that this point must be far enough outside the shackle to give a length of chain sufficient to lead out through its own hawse-pipe and in through the other pipe to the point where it is to be shackled to the swivel, which will be a short distance inside the other hawse-pipe. Both chains are now broken at the shackles and the riding chain is connected up to the swivel. At the same time, the lee chain is hauled around by the dip-rope, the bight of the chain being eased out by the bight of the hook-rope, as shown. The chain is thus kept under control and the heavy surge on the clear-hawse pendant which would result from letting the bight go out by the run, is avoided.

As soon as the riding chain is shackled up to the swivel, the strain of the chain is taken with the anchor-engine. The slip-

hooks of the deck-stopper and the preventer are knocked clear, and the chain is eased out until the swivel is just inside the hawse. This reduces the length required on the lee chain to reach the swivel, and so gives a tauter moor. The lee chain having been hauled inside is shackled to the swivel.

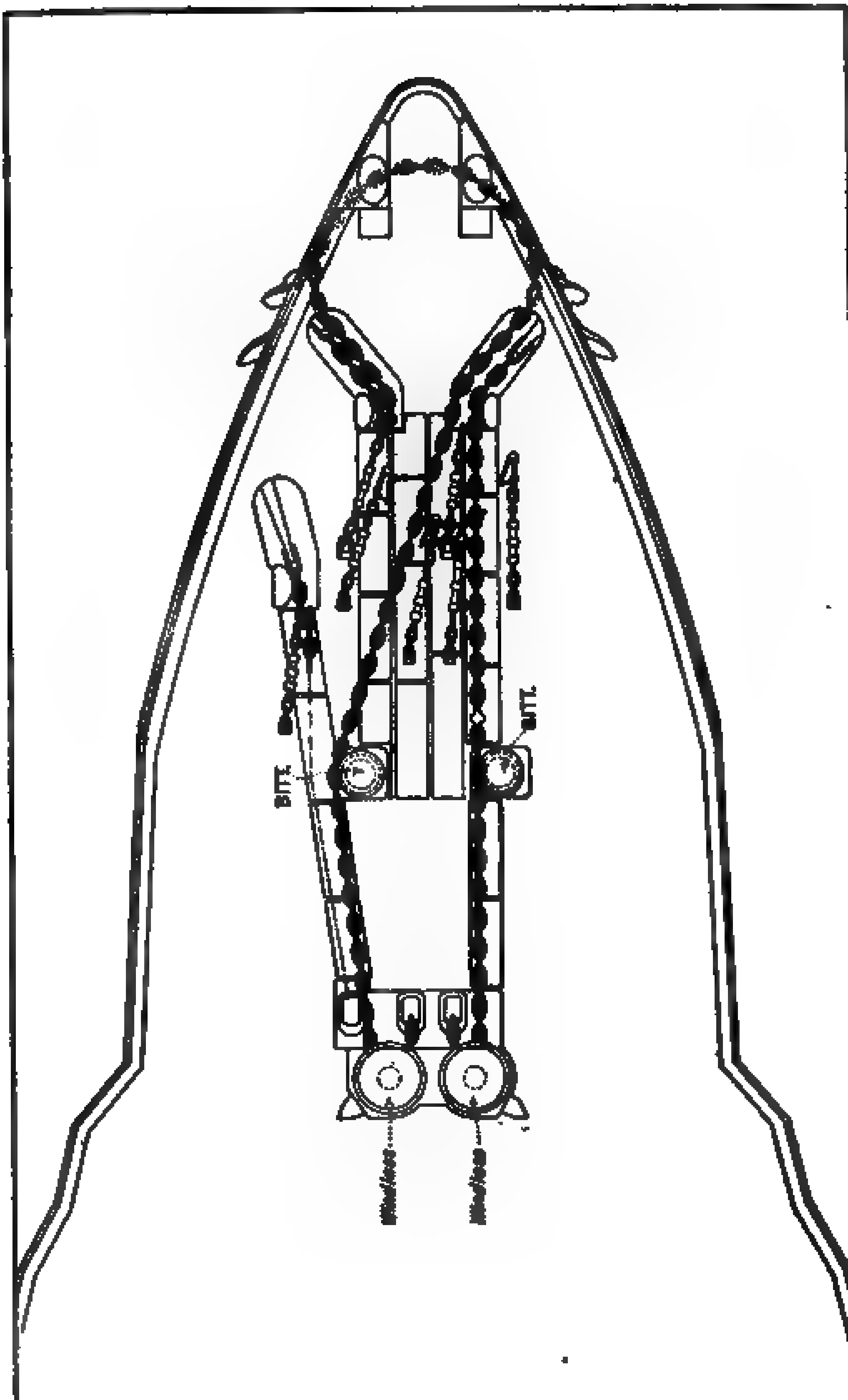
The slip-hooks of the clear-hawse pendant and the preventer are now knocked clear of the lee chain, allowing the bight to run out, after which the swivel is veered outside.

Fourth Method. Plate **86.** This method was developed by Chief Boatswain M. H. Eldridge, and used by him on the U. S. S. Wyoming. It goes farther than either of the preceding methods in reducing the amount of gear that must be used, and, what is more important, provides for doing most of the work required in advance of the time of actual mooring and while the ship is approaching the point where the first anchor is to be dropped.

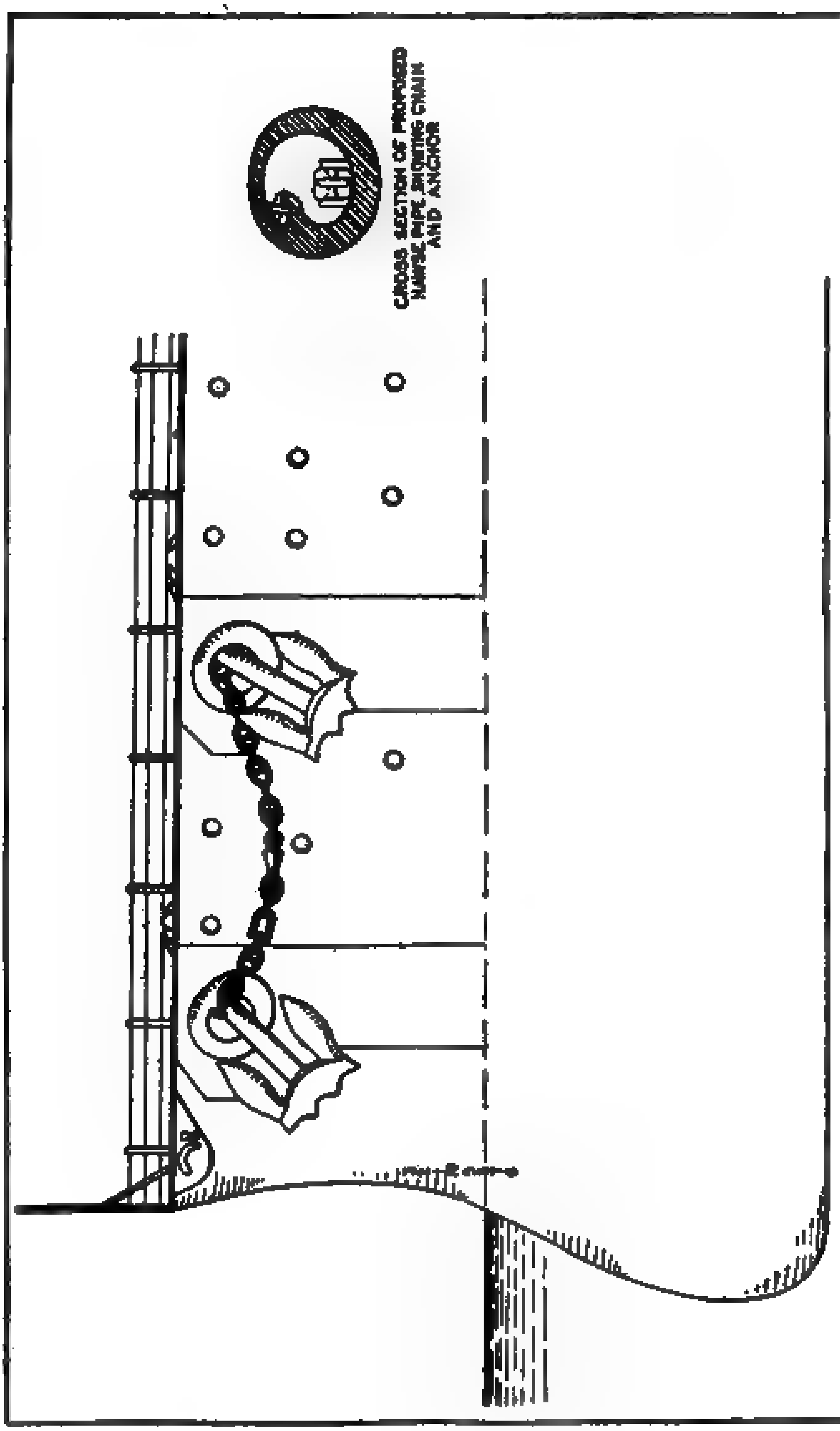
The starboard anchor is lowered and hung by one slip-stopper, ready for letting go. The port anchor is lowered and hung by two slip-stoppers and the port chain unshackled at five fathoms, after which the after-length of the chain is dipped outside the port riding-bitt and hauled across the forecastle to a point near the starboard hawse-pipe. The dip-rope is rove out through the port hawse-pipe, across the stem, and in through the starboard hawse-pipe, where it is bent to the free end of the port chain. The port chain is next hauled by means of the dip-rope out through the starboard hawse-pipe, across the stem and in through the port hawse-pipe, where it is shackled up to the five-fathom length which has remained attached to the anchor. The port anchor is then eased down until the after-stoppers take the strain. The dip-rope is unbent and gotten out of the way, and all is ready to moor without the further use of a single piece of gear.

When in position for dropping the first anchor, if a flying moor, the starboard anchor is let go and the chain laid out. While the starboard chain is running out, a sufficient length of the port chain is roused out through the starboard hawse-pipe to insure the port anchor reaching the bottom without a sudden jerk of the chain. The forward stopper is now taken off the port chain, leaving the anchor hanging by one slip-stopper ready for letting go.

As the ninety-fathom shackle comes to the proper point (dependent upon the depth of water and the tautness of moor de-



MOORING AND PUTTING ON THE SWIVEL—FOURTH METHOD.



MOORING AND PUTTING ON SWIVEL WHEN BOTH ANCHORS ARE ON THE SAME BOW.

sired) the port anchor is dropped, and the chains are adjusted to forty-five fathoms on deck. Two stoppers are now put on each chain, the cables are unshackled, and the two forward lengths shackled to the forward links of the mooring swivel. The after-length of the starboard chain is shackled to one of the after-links and the mooring swivel is veered outside.

If, instead of making a flying moor, the ship is to back away from the first anchor dropped, the port anchor must be let go first, the rule being that the anchor let go "on the bight" should always be the one to tend ahead.

The convenience of the method above described is even greater in cases where the two anchors to be used are on the same side of the bow, than in the case above described where they are on opposite sides, for the reason that in this case there need not be any large bight of chain hanging over the bow while the ship is approaching her anchorage and while she runs out the first chain. Plate **87.**

A trifling inconvenience connected with the Eldridge method is the fact that the port chain lies in the starboard hawse-pipe, alongside the starboard chain, during the time that the starboard chain is running out. This is not at all a serious matter, but a hawse-pipe has been designed and is under consideration for installation in future ships, which includes a lip on the inside of the hawse-pipe by which the chains can be held clear of each other. The details of this design are shown on Plate **87.**

If the swivel cannot be put on either cable inside, it must be put on the lee cable first, the shackle being veered outside, the cable secured by the clear hawse-pendant and a hawser, and the swivel lowered over the bow and put on by men working in a boat or on a stage. When the ship has swung, bringing the other cable to leeward, this is handled exactly as has been described for connecting the lee cable in the case where the swivel was put on the riding cable inside and veered outside.

Taking off the Swivel Outside (Plate **84**).—Secure the lee chain as for clearing hawse; that is to say, put the clear-hawse pendant and preventer hawser on that part of the lee chain leading from the anchor and heave in on the clear-hawse pendant until there is slack enough between it and the swivel for unshackling. If the inboard end of the lee chain is shackled to the swivel, stick out slack enough for unshackling it also. If this end is

not attached to the swivel, haul it out by the dip-rope leading from the weather sheet pipe. Hang both parts of the lee chain by good lines from the forecastle. Unshackle both ends from the swivel and shackle them together. Heave the lee chain taut, take off the hawser and slip the clear-hawse pendant. Heave in on the riding chain until the swivel is abaft the controller. Secure the chain by stoppers, unshackle the ends from the swivel and shackle them together.

If the swivel will not go through the hawse, it is desirable to wait for the ship to swing before taking it off the second chain. Thus each chain is a lee chain when it is disconnected.

If it is impracticable to wait for this, handle the riding cable as already described for the lee one, but with extra precautions. The clear-hawse pendant may still be used, but the preventer hawser must be a good one and must be hove taut. The ship in fact rides by this hawser and not by the clear-hawse pendant, while the chain is slacked for unshackling. Steam should be ready, and an officer should be on the bridge ready to work the engines. By giving a turn ahead from time to time the tension on the hawser can be relieved and there should be no danger in the operation.

All working of chain where unshackling is necessary should be done at slack water or as near it as possible.

TENDING SHIP.

When the swivel is not used, it is very important to "tend ship"; that is, to watch the swinging at each turn of the tide, note the direction in which the stern swings, always recording this in the log, and, taking advantage of any conditions which may be helpful, try to make the ship swing to that side which will keep the hawse clear, or clear it if it has already fouled.

It is well to give some attention to "tending ship" even when the swivel is in use. The purpose of the swivel is to prevent the hawse from fouling, but unfortunately it does not always work. It is especially likely to fail if the moor is slack, and in this case the chains may foul so far below water that it will not be known that they are foul until the ship starts to get underway. It is not unusual to find cables very badly fouled when every confidence is felt that they are perfectly clear. *It is very important to watch the swivel while the ship is swinging and to note whether it works*

or not. If it does not, it may be practicable to heave it around by a purchase hooked to that part of the chain which should be lifted. To assist in keeping track of the working of the chains, it is a good plan to paint a few shackles of each chain just outside the swivel, using red for the port and white for the starboard cable.

If there is any room for doubt as to the cables being clear, it is a good plan to underrun the riding cable for some distance ahead of the swivel with the bight of a boat chain.

CHAPTER X.

CARRYING OUT ANCHORS.

§ 1.

Important changes have been introduced into all problems connected with the handling of anchors, by changes within recent years in the character of the anchors themselves and in the methods of stowing and handling them.

All ships of recent design carry stockless anchors, and the bowers and sheets of this type are, in a great majority of cases, housed in the hawse-pipes, although on many ships one sheet anchor is still carried on an anchor-shelf. Plate 79. Where this last arrangement exists, an anchor-davit is necessarily provided; and even where all of the anchors house in the pipes, a davit is frequently fitted, for general convenience in the handling of ground-tackle.

Anchors which stow in the hawse-pipes are not fitted with balancing-links and must be handled by straps. These may be placed at the balancing point, thus serving the same purpose as the usual link, or they may be passed around the crown, where they allow the anchor to hang more or less "ring-heavy." The last arrangement has some advantages, as will be explained hereafter. Anchors which are fitted with links are usually handled by means of these.

Most men-of-war carry "**stream**" and "**stern**" anchors, of from one-fourth to one-third the weight of the bowers. These are not too heavy to be carried out by a single boat, and the problem of handling them presents no great difficulty, provided the method to be used has been thought out beforehand and all the fittings prepared.

It is quite a different proposition to deal with a bower anchor, weighing from fifteen to twenty thousand pounds, and stowed without any thought of the possible necessity for carrying it out by boats.

It is held by some seamen that the necessity for carrying out a bower is so unlikely to arise under modern conditions that it is not worth while to prepare for it. In support of this view, it is pointed out that the engines of modern ships are so powerful in comparison with any pull which could be put upon a line for haul-

ing off a stranded vessel, that they are, and must be, the main reliance; and that if they do not suffice there is little hope of accomplishing anything without help from sources outside the ship.

It is true that the main reliance of a ship which goes aground will be upon her engines and upon outside assistance, provided the engines can be used and that outside assistance is available. But the engines can only be used while the stern is tailing off into deep water; and in many, perhaps in most, cases, there is a tendency to swing around broadside on to the beach, when the engines immediately become worse than useless and the problem to be dealt with by outside assistance, if at hand, is of enormously increased difficulty.

As is pointed out in the chapter on "**Stranding,**" the first thing to be done when a vessel goes aground and refuses to back off at once is to hold her from being set farther up by a rising tide, and *to hold her stern off from the beach so that her engines may continue available for use.* Under reasonably good conditions, an anchor of medium weight may suffice for this, but there are many conditions where nothing short of the bower or sheet will answer. It is not here a question of hauling off—the winches would hardly furnish power enough for this—but only of *holding* against wind and tide; although it is by no means unusual for a ship to yield to the steady strain of a taut line and to come off altogether unexpectedly.

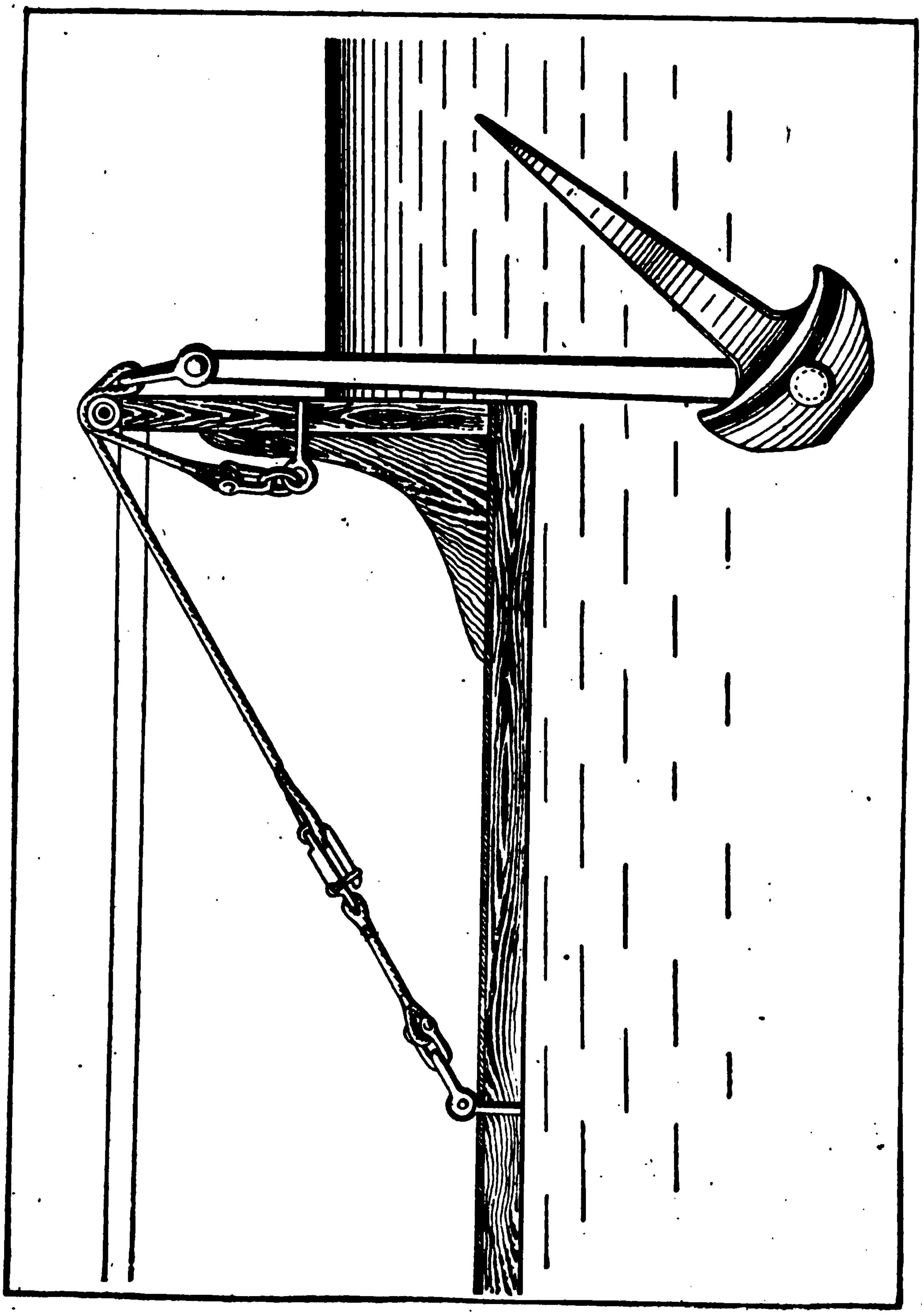
If proper preparations have been made beforehand and tested by frequent drills, it should be possible to carry out the stream or stern anchor within ten minutes, and to follow this by a bower within from thirty to forty-five minutes more.

§ II.

First Method. The simplest way to carry out an anchor is to hang it from the stern of a launch as in Plates **88** and **89**, but this utilizes only a part of the floating power of the boat and is not practicable with a very heavy anchor. The weight which can be carried in this way may be much increased by adding weight at the bow, thus counterbalancing the weight at the stern and bringing the boat more nearly onto an even keel. In this way the boat may be made to carry at the stern approximately one-half of its total floating capacity, whereas it would not carry anything like this at one end without a compensating weight at the other.

A convenient way of hanging the anchor and letting it go is illustrated in Plate **88**, where one end of the wire strap is shackled

Plate No. 88.



CARRYING OUT ANCHORS; FIRST METHOD.

to the ring of the anchor, while an eye in the other end engages a slip-hook secured to a ring-bolt in the keel of the boat.

NOTE.—In all cases where an eye is to engage a slip-hook, the eye must be made large enough to allow the tongue of the hook to run through it freely when released. The eye is better without a thimble.

For a light anchor, a manila strap may be used and secured with a toggle as in Plate 89.

To provide for weighing, a **weighing-line**, usually of wire, is bent to the crown of the anchor, and fitted with a **buoy-rope** and buoy.

The **hauling-line**, of manila or wire, is bent to the ring of the anchor and leads to the ship.

Running the Line. With a light anchor it may be assumed that a manila hawser will be used for a hauling line. In this case the end of the line is bent to the ring and the line is payed out from the ship as the boat pulls away; a considerable length of the line, however, being coiled in the stern-sheet ready to be thrown out from the boat as the point is approached where the anchor is to be planted. The throwing over of this part of the line at the last gives freedom of control to the boat at a point where the long bight of the line, dragging astern, would otherwise be embarrassing.

In some cases, with a manila line, it is better to coil the whole length of the line in the boat and carry it out with the anchor, paying it out as the boat pulls back to the ship after planting the anchor. This is especially convenient when the anchor has to be carried out against or across a strong wind or tide.

In all cases where any part of the line is carried in the boat, enough of it must be thrown over before letting go, to make it certain that the anchor will reach the bottom with plenty of slack line to spare.

Where a *wire* line is to be run, it is always better to send the end away with the anchor, and pay out the line from the ship, although here, as in all other cases, a few fathoms should be coiled in the boat. The difficulty in dealing with a large coil of wire-rope in the boat is connected in part with its stiffness and its tendency to *kink*, and in part with its disposition to " take charge " if the stops by which it is being towed should part.

A convenient way to secure the line to the boat when paying out from the ship is shown in Fig. 2, Plate 91. The stopper used may be either a single line or a span with one part leading to each quarter of the boat.

CARRYING A KEDGE WITH A CUTTER.

It is sometimes practicable to take a wire line in a boat, *on its reel,* the reel being lashed very securely in place on a temporary platform. The line can then be payed out directly from the reel.

It is important in running a line to head well up against any wind or current which may be setting across, and to remember that the boat will not steer if her stern is bound by a taut line.

If a long scope of line is to be run out, one or more boats should take the weight of the bight, holding it by slip-ropes from the bow and stern ring-bolts.

In all cases of carrying out an anchor except when dealing with a light kedge, it is well to *tow* the boat from which the anchor is hung, using for this purpose a steam-cutter if one is available.

Where the anchor is very heavy, a good plan is to lay out a kedge some distance beyond the point where the anchor is to be planted and to haul out by a manila line bent to the ring of the kedge.

Second Method. Plate **90.** This is a very convenient method provided preparations have been made for it in advance. In the British Navy the straps and other fittings are issued to ships and are kept ready for use at a moment's notice.

A "**spreader**" is called for here, to relieve the crushing strain on the sides of the boat. This may rest on blocking, as in Plate **90**, or, if the anchor is not too heavy, on the gunwales of the boat. It is well to lash the spreader to a thwart and also to seize the "**belly-strap**" temporarily to the spreader, taking care to cut the seizings before letting go.

The anchor may be hung by the balancing-link if one is fitted, or better, by a strap around the shank and crown as shown in the plate. With this strap the anchor will hang more or less "ring-heavy," which makes the strap available for breaking out and weighing the anchor, *crown first.*

It is often practicable to break out the anchor and drag it home, crown first, by a line from the crown to the ship. (See § III of this Chapter.)

The **hanging-pendant** must be long enough to reach from the ring under the keel to the water's edge, where it is shackled to the anchor-strap.

The use of the **lowering-rope** between the fish-pendant and the anchor-strap admits of unhooking the fish-pendant after the anchor is lowered into place under the boat.

The **weighing-line** is shackled to the end of the lowering-rope

after the fish-pendant is unhooked, or sooner if the eye is large enough.

As the weighing-line will, in most cases, be of wire, a **buoy-rope** is needed for recovering the end.

In all cases like the present one, where the hanging-line from the boat leads off at an angle at the time when it begins to take the weight of the anchor, a strong pull will be exerted dragging the boat *toward* the anchor. This is not necessarily a matter of great importance, but is a factor to be reckoned with. As its tendency is to draw the boat against the lowering-rope, it is well to use a **chafing-spar** alongside to protect the bilge. The launch's mast may conveniently be used for this. Plate **90.**

The **hauling-line** leads from the ring of the anchor to the ship. It is usually bent to the ring and run out with the anchor as has been described in connection with the First Method above. A better way, with a heavy anchor, is to use a **hauling-pendant** on the ring of the anchor, long enough to reach well above water when the anchor is let go. The boat holds on by this pendant (or by a lighter line bent to the eye), and the real hauling-line is sent out by another boat and shackled on. By thus carrying out the anchor and the line separately much trouble is saved.

Ten fathoms is a convenient length for the hauling-pendant, and should answer for all ordinary demands, although it may, of course, become necessary to lay out an anchor in water much deeper than this.

If it is preferred not to let the anchor hang "ring-down," a manila line may be bent to the ring and brought in over the stern of the boat, holding the ring well up under the keel. A 5-inch manila line should be large enough for this, even with a heavy bower. Or the hauling-line may be utilized for this purpose, the bight being stopped up to the boat and holding the ring up.

Of course, if the anchor has a balancing-link it may be handled altogether by this; in which case, however, the weighing-line must be bent independently to the crown to admit of breaking out the anchor-crown first. In this case the lowering-rope and hanging-pendant are shackled to the balancing-link.

In the absence of a balancing-link, the anchor may be balanced perfectly by a strap passed around the shank at the balancing point—which is never more than a few inches from the crown—and held from slipping by a lashing around the crown. No lashing from the ring is necessary as the very short distance which

the strap could slip toward the crown would be of trifling importance.

Under ordinary conditions, however, there is no disadvantage in allowing the anchor to hang ring-heavy, supporting the ring if necessary as in Plate **90**; and the arrangement of lines and straps there shown will in general be found convenient.

In dealing with a bower or sheet anchor, it is necessary to provide for unbending the chain. It is convenient to disconnect either at the 5-fathom shackle or at the end of the **triplet**, and to bend the hauling-line to the end of the length of chain which remains on the anchor instead of directly to the ring.

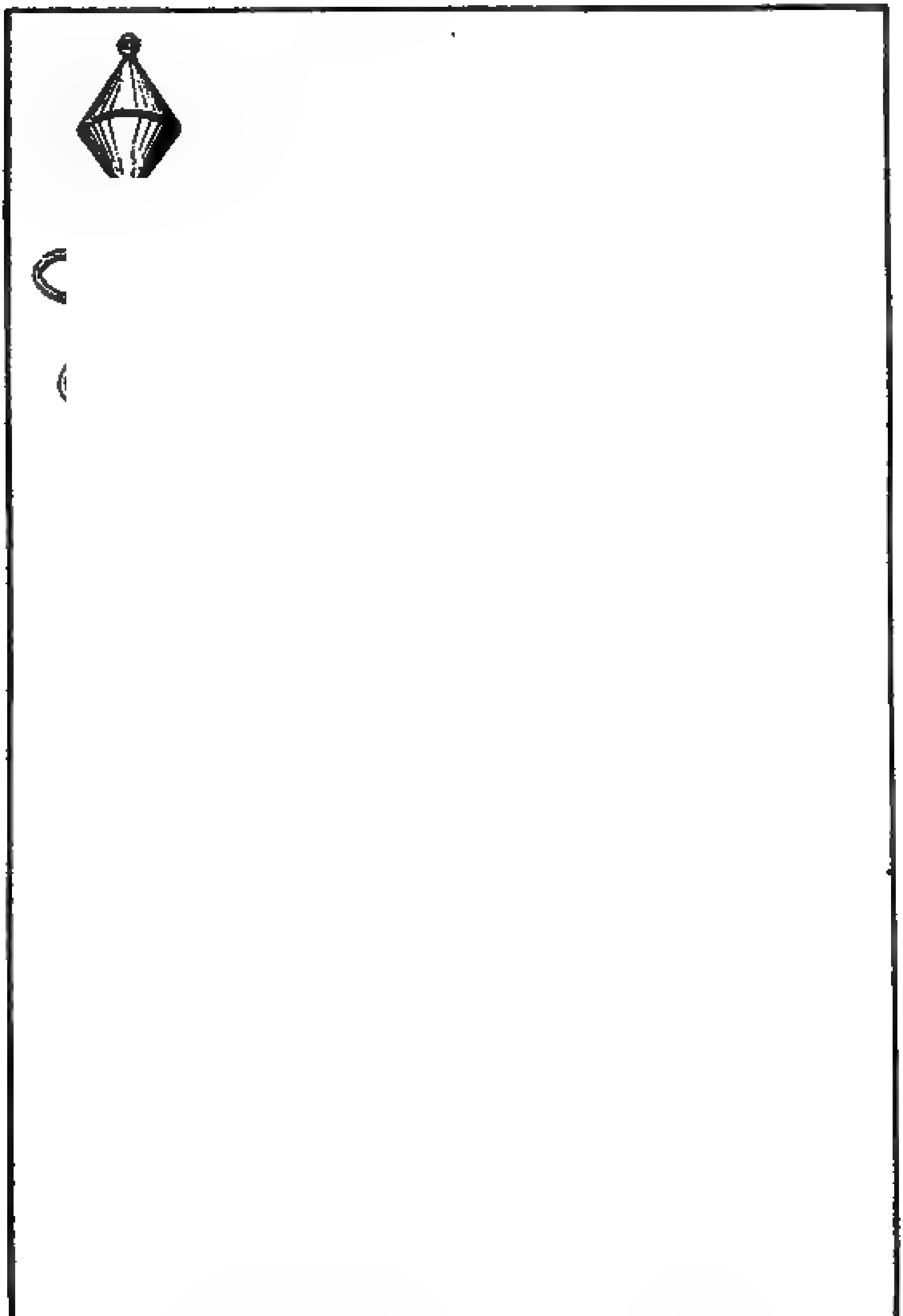
The shackle may be veered outside and handled there or we may bend a wire hawser to the cable inside, just forward of the shackle, take it to the winch and haul taut, after which we unshackle and veer away by the line.

In handling the chain outside, the weight is taken by slip-ropes and jiggers from the forecastle.

It is often very difficult to handle a boat under the bow; as for example, when there is a heavy sea running, or a strong current. Under such circumstances one or more kedges may be laid out and the boat controlled by lines from these, and from the ship.

If the ship is not fitted with an anchor-davit, or if for any reason the anchor cannot be handled under the bow, the **boat-crane** must be used, a heavy block being lashed to the head of the crane and a wire line led through this and taken to the bow, or wherever else the anchor is stowed. If dealing with a bower or sheet, the line is bent to the anchor-strap on the crown, and the anchor is *let go* and hove up to the crane, crown first, where it is handled as may be desired. Under many circumstances this plan is more convenient than any other, even though an anchor-davit is available.

It would probably be practicable under favorable circumstances —everything being quiet under the bow— to take the anchor directly from the hawse-pipe, as follows: A strap is put on the crown and the anchor is eased down until the crown is awash. The hanging-pendant is brought around the bilge of the boat and shackled to the strap. A large kedge is planted off the bow with a good line for holding the boat clear. A wire-hawser, technically a **veering-line**, is shackled to the cable just forward of the 5-fathom shackle, taken to the winch and hauled taut. The chain is now unshackled and the anchor is eased down by the wire line until it hangs by the crown under the boat.



CARRYING OUT ANCHOR SECOND METHOD.

In lowering away under these circumstances, the force tending to drag the boat toward the anchor and against the chain will be very strong, and a good chafing-spar will be needed to protect the bilge of the boat.

The wire line may be left shackled to the chain from the anchor and be sent out with the anchor as a hauling-line, or it may be unbent and replaced by another line. The length of cable which remains bent to the ring of the anchor takes the place of the lowering-rope and gives drift enough to admit of unbending the veering-line.

Third Method. Plate **91.** This resembles the Second Method, but with the difference that the hanging-pendant slips on the bight of the belly-strap and may thus be made very much shorter, as it can be slipped up to the water's edge, or above, and need only be long enough to admit of convenient handling for shackling to the eyes of the anchor-strap.

As the anchor is lowered away, the eye of the hanging-pendant slips down until the anchor hangs below the keel. It is well to leave the belly-strap rather slack so that the eye may slip down freely.

The spreader is lashed to the thwart and the belly-strap seized temporarily to the spreader as in the Second Method.

To make sure of recovering the belly-strap—which might unreeve after letting go—a light manila **doubling-line** may be passed around under the boat and bent to the ends of the belly-strap.

Fourth Method. Plate **92.** When it becomes necessary to carry out a very heavy anchor, like the bower or sheet of a battleship, the only practicable method is to put two launches alongside and hang the anchor between them from a spar.

Here it is convenient to handle the anchor (stockless) by the ring, bending the weighing-line independently to the crown. Except for this change, the anchor is handled substantially as in the methods already described.

The anchor is eased outside the hawse-pipe until the fish-pendant or lowering-rope can be shackled to the ring. The strap is put on the crown at the same time, and the weighing-line shackled to it. The chain is then veered, and the anchor swings to the fish-pendant.

In the meantime the boats have been prepared and hauled forward and two kedges have been planted where they will give the best control, with a line from each to the bow of one of the boats. A line from the stern of each boat to the ship completes the ar-

Fig. 1.

Fig 2.

CARRYING OUT ANCHORS: THIRD METHOD.

rangement for holding the boats stern-on to the ship's side; provided, of course, that conditions make it desirable to hold the boats in this position. In any case, it will be well to have at least one good kedge for holding off, as the drag of the anchor on the hanging-pendant while being lowered into place will be very strong.

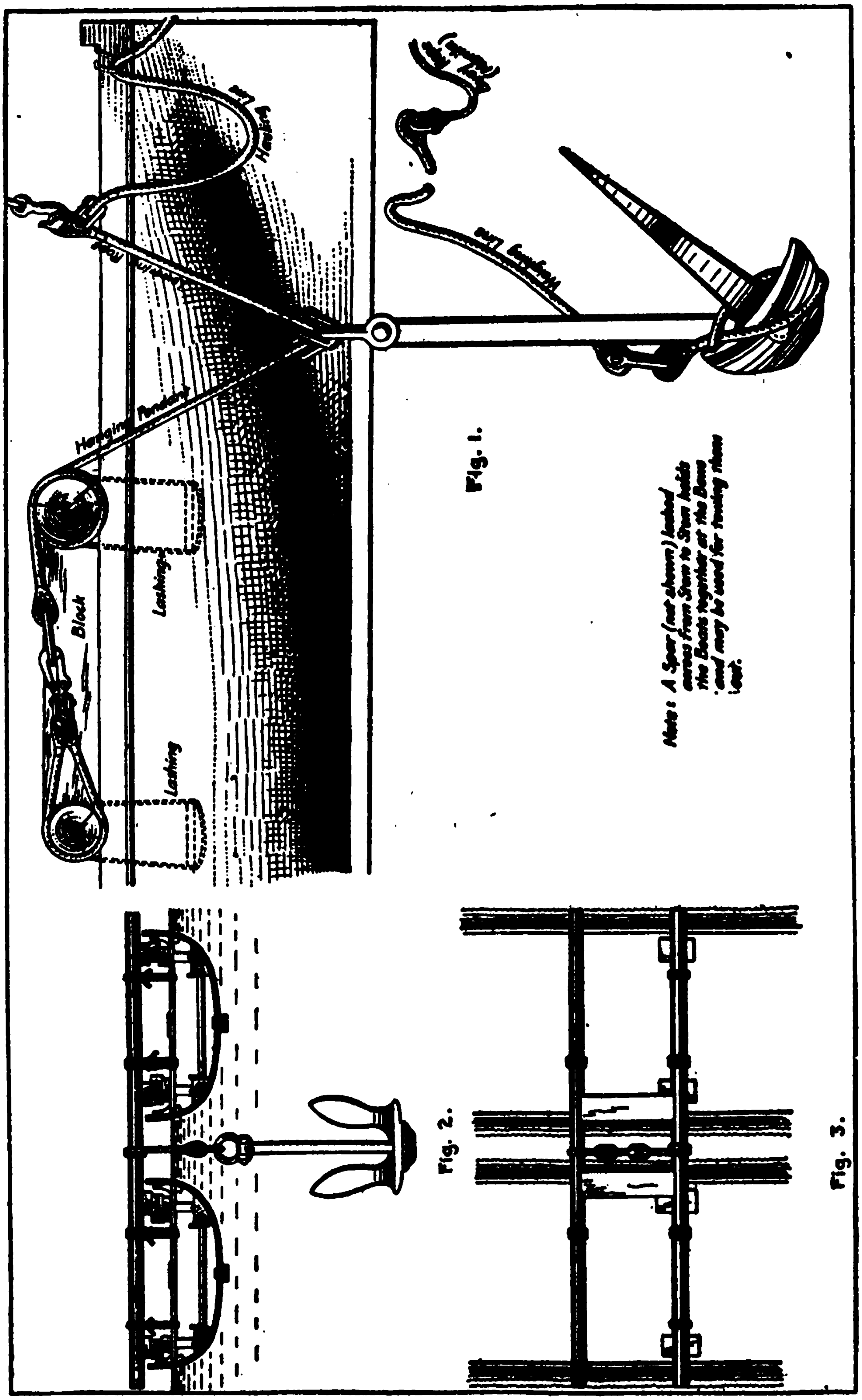
Assuming that the boats are held stern-on, the hanging-pendant is passed aft between them and shackled to the ring of the anchor at the water's edge. The chain is then unshackled, as has been described in connection with the Second Method, and the anchor is eased down into position, the fish-pendant passing between the boats, which will have a strong tendency to surge aft in obedience to the drag on the pendant.

The anchor may, of course, be handled by the crown instead of by the ring, without changing any principle of this method, and it will be convenient to adopt this plan if the water is rather shallow.

If the boats cannot be held stern-on, the hanging-pendant must be dipped under the inner boat, as in the Second Method. Here a long pendant will be needed, and the anchor will necessarily hang rather deep. Assuming 10 feet for the beam of the boat, the pendant from the spar to the crown of the anchor would be approximately 16 feet, and allowing 4 feet more for the anchor we have a total depth of 20 feet. As a ship carrying a boat of 10 feet beam would draw at least 28 feet normally, this would probably be all right; but if not, measures must be taken to insure holding the boat stern-on, when the anchor, if handled by the crown, can be hung well up under the boats.

In an extreme case, the water being very shallow, the hanging-spar may be put well aft on the boats (sacrificing something in flotation), and the boats backed in against chafing-mats on the ship's side, *directly over the anchor,* which in this case must be well below water; the hanging-pendant (not yet passed around the spar) having been already shackled to the strap on the crown. The hanging-pendant is then passed around the spar, shortened in as much as possible, and secured; after which the anchor is lowered into position where it will hang only just clear of the boats.

In some cases it may be well to drop the anchor from the bow and pick it up on the boat-crane, where it can be held in any desired position, suitable lines for weighing by the crane being bent to the anchor before it is let go, or eased down, from the bow. An anchor hanging from the boat crane can be controlled more easily than by means of any device available at the bow.



CARRYING OUT ANCHORS. FOURTH METHOD.

The plan shown in Plate 92 for securing the hanging-pendant and letting go is very convenient, but it must be remembered that *unless a turn is taken with the pendant around the spar, the strain on the spar will be approximately double the weight of the anchor,* as the spar will in such a case play the part of a pulley. By taking a turn, this effect is practically annulled.

It is well to make the slipping end of the pendant as short as possible, to avoid the dangerous "whip" which would result from a long end when released.

Steadying-lines may be used from the flukes of the anchor, but must be cast off before letting go.

The plan described in connection with the Second Method for taking the anchor from the hawse-pipe is equally applicable with the present method, subject to the limitations which have been pointed out with regard to the depth of water.

The boats may be towed out by a steamer, or a kedge may be planted beyond the point where the bower is wanted, and the boats hauled out by a line from the kedge. Where conditions are unfavorable, as for example where the boats must be hauled out against a strong wind or tide, it is a good plan to lash a large single block to the ring of the kedge and reeve through this a good manila line, bringing both ends of the line back to the ship. By bending one end to the spar across the bows of the boats or to a span from the bows, and taking the other end on board, the boats may be hauled out by the winch.

DIAMETER IN INCHES OF A ROUND SPAR OF A GIVEN SPAN, TO CARRY A GIVEN LOAD AT THE MIDDLE POINT.

Safe load in pounds.	Span in inches.					
	18	24	30	36	42	48
6,000	6″.8	7″.4	8″.0	8″.3	8″.8	9″.0
8,000	7″.2	7″.9	8″.5	9″.0	9″.5	9″.9
10,000	7″.7	8″.5	9″.1	9″.7	10″.2	10″.7
12,000	8″.2	9″.0	9″.7	10″.3	10″.9	11″.4
14,000	8″.6	9″.5	10″.2	10″.9	11″.5	12″.0
16,000	9″.0	9″.9	10″.7	11″.4	12″.0	12″.5
18,000	9″.4	10″.3	11″.1	11″.8	12″.5	13″.0
20,000	9″.7	10″.7	11″.5	12″.2	12″.9	13″.5

A square beam the side of which is equal to the diameter of a round spar in the above table will support 1.7 times the load of the round spar.

Conversely, a square beam to support a given load must have $\frac{8}{10}$ the thickness given above for a round spar.

The preceding table shows the size of spar required to carry a given weight, with a given distance between points of support. There is of course a difference in the strength of different varieties of wood, but the spars which are likely to be available on shipboard are of about the same general character, and the figures here given, which are for good sound pine or spruce, may be used with confidence for all ordinary woods.

The weight which can be carried varies directly with the *cross-sectional area* and inversely with the *span;* that is to say, the distance between points of support. A given spar spanning 24 inches between supports will carry twice as much as if the span were 48 inches.

Safe Floating Power of Navy Boats for 2d, 3d, and 4th Methods Preceding.

Boat.	Floating power.	Remaining freeboard.	
	Lbs.	*Inches.*	
40-foot launch....	16,000	28	Load may be safely increased in smooth water.
36 " "	12,000	24	
33 " "	10,000	23	
30 " "	7,500	21	
30-foot cutter....	7,000	16	
28 " "	6,000	14	
26 " "	4,500	12	
24 " "	4,100	12	

Safe Floating Power at Stern with Compensating Weight at Bow.

Boat.	Load at stern if bow is loaded.	Load at forward end of boat.	Number of men required at forward end.	Approximate remaining freeboard at stern.
	Lbs.	*Lbs.*		*Inches.*
40-foot launch........	8,000	8,000	65	24
36 " "	6,000	6,000	45	20
33 " "	4,500	4,500	35	18
30 " "	3,000	3,000	23	16
30-foot cutter	2,500	2,500	18	13
28 " "	2,000	2,500	18	11
26 " "	1,500	2,000	15	9
24 " "	1,000	1,500	12	9

The weights in the bow should, if possible, be men, and these should be grouped as far forward as is practicable. When the

anchor is let go, the men must be prepared to move quickly aft, as the bow will dip suddenly.

§ III.

To Pick Up an Anchor.

Where an anchor has been carried out for any purpose, it may be assumed that a weighing-line has been bent to the crown either as described in the preceding section or in some other efficient way. In this case the simplest way to pick up the anchor is to run a line from the ship to the end of the weighing-line and drag the anchor home crown first and run it up to the hawse-pipe. This plan very greatly simplifies the matter of using an anchor for such temporary purposes as hauling the stern around for bore-sighting, for sub-caliber target practice, or for improving ventilation in a tropical climate.

If conditions are such that the anchor cannot be hauled home by the ship, it must be weighed by a boat, and this will not be very difficult if the anchor is of moderate size, and if it can be broken out by the crown. If no line has been provided from the crown, a diver should be sent down to bend one on.

To Weigh an Anchor by a Boat. An anchor of medium size may be weighed by a boat by bringing the line in over the stern roller and applying a purchase of any convenient kind; a luff upon luff, an improvised windlass, or any other device which may be suggested by the conditions. The flotation of the boat can be utilized to start the anchor, a convenient way being to fill the stern-sheets with men and heave the line well taut, then to shift the men forward to the bow. By letting them "sally" forward on the run, the anchor may sometimes be jumped out. It is only necessary to lift the anchor far enough to admit of carrying it back to the ship.

If there is no weighing-line from the crown of the anchor, and if circumstances do not admit of sending down a diver to bend one on, the anchor must be broken out by the ring. In such a case it is especially important to use a line from the ship, although a small anchor can, of course, be handled, even in this way, by a good-sized launch. A battleship's launch, for example, should be able to deal with a 3000-pound anchor very easily, and in some cases—when the anchor is not holding very strongly—with one of double this size; that is to say, with the "stern" anchor which is now supplied to all battleships.

In cases of especial difficulty it might be well to put two launches alongside, connecting them with a spar as in Plate 98, and make use of their power of flotation by loading them deeply with men, hauling taut the line from the anchor to the spar, and then removing the men. Two 36-foot launches, holding 100 men each could be made in this way to exert a pull of 30,000 pounds.

LOST BOWER OR SHEET.

Where a bower or sheet anchor has been lost by the parting of a cable, the problem is quite different from that of dealing with a lighter anchor such as might have been carried out by the ship's boats.

Here it will usually happen that a certain length of chain is attached to the anchor. The problem is, in this case, for the ship to get hold of this chain and weigh the anchor with her windlass. This means, first of all, that the ship must place herself near the anchor, but of course not close enough to interfere with working lines from a boat. If the anchor is buoyed, it is located without difficulty. If not, it must be found, and the easiest way to find it is to drag for the chain across the line on which it is supposed to lie. A grapnel may be used for dragging but it is better to take a kedge anchor, to the stock of which a capstan-bar is lashed to keep the fluke down.

The chain having been grappled, it may be possible to lift the bight or the end and bend on a line from the hawse-pipe, by which the ship can haul over at once and pick up the anchor. For this the boat that has found the chain would lift the bight or hold on by the grapnel and send down a diver to bend a 6-inch or 7-inch manila line to the chain near the end. Such a line should answer for lifting the chain and probably for hauling the ship into position, but it would not weigh the anchor. If the chain is not long enough to admit of bringing the end inside the hawse, the end of a good wire line is sent out to the boat and shackled by the diver to a link near the end, but not to the end link.

Where the anchor to be dealt with weighs upward of ten tons, as do the bower and sheet anchors of a superdreadnaught, it is out of the question to weigh it with any line which could be handled by a diver. The heaviest manila hawsers supplied to ships are 10 inches in circumference and are not strong enough

to break out the anchors in question. Nor could any diver hitch a line of this size to the crown of an anchor. A wire hawser would be strong enough, but wire does not work well on the nigger-head of a winch.

The following plan combines several advantages. It provides a perfectly manageable wire line to be shackled (not hitched) to any part of the anchor that can be reached. It provides a length of chain-cable for shackling to the ship's cable, belonging, it may be, to the lost anchor, and it provides an ample length of manila hawser for weighing the cable and the wire and for hauling the ship into place over the anchor. The plan is as follows:

A 5-fathom shot of chain is shackled at one end to a pennant of 4½-inch wire eight or nine fathoms long, and at the other end to a 6 or 7-inch manila hawser. The shot of chain and the wire pennant are slung outside a motor sailing launch, the manila line is coiled in the stern sheets, and the boat proceeds to a point near the anchor. Here enough of the manila line is thrown over to reach the bottom, the chain is paid down on top of this, and lastly the wire pennant is paid down on top of all, where it is easy for the diver to handle it; the diving boat gets into position, and the diver goes down and shackles the wire pennant to any part of the anchor that he can reach conveniently. The motor-sailer takes the manila line back to the ship and it is hauled in through the hawse-pipe and taken to a winch.

The ship manœuvres into a position as nearly over the anchor as is practicable, and heaves in the line. When the chain comes in it is shackled to the free end of the cable on board and the anchor is hove up and hung by a stopper, after which the cable is bent to the anchor in place of the wire pennant.

If the water is too deep for diving, and if the chain is not long enough to be picked up by grappling, the chances of recovering a *stockless* anchor are hardly worth considering.

With an old-fashioned anchor the case is quite different. Here we may hope to catch the upper fluke by dragging the bight of a light chain, or of a rope weighted at two or more points, across the place where the anchor is known to lie. When the fluke is caught, a shackle may be put around the two parts of the dragging rope and allowed to slip down, binding them so that they cannot become disengaged.

If the anchor is not buoyed, we may assume that its position

can be fixed within narrow limits by bearings, and the first thing to be done will be to locate it exactly and to mark it by a buoy.

We then proceed as before, utilizing a diver if practicable, or dragging for the bight of the chain.

NOTE.—In all cases of dragging for an anchor or a chain, it is important to mark by floats the area covered as the work progresses.

CHAPTER XI.

THE STEERING OF STEAMERS.[1]

§ I.

The elements which enter into the steering of a screw steamer are so many, and their effects are so varied and conflicting, that any attempt at an exhaustive analysis of them would be altogether out of place in a work on practical seamanship. It is proposed here merely to name and briefly discuss the most important of them and to explain such of their effects as enter practically into the handling of a ship. In this discussion it will be assumed, where not otherwise stated, that all conditions are normal and average; that is to say, that the ship is of medium size and draft and loaded to her mean water-line; that she has no unusual features of design; that she draws rather more water aft than forward; that her rudder is of the ordinary type and of medium size, and fitted to a rudder-post immediately abaft the propeller-well. It will be assumed also, except where the contrary is stated, that the weather is calm.

For simplicity, the discussion will be confined to a right-handed screw, so that all which is said of the effects of the screw upon the steering must be exactly reversed for a vessel with a left-handed screw.

Twin-screws will be treated in a separate section.

The factors which we shall consider as entering into the steering of a steamer are the following:

[1] The United States Navy has recently adopted the terms *right rudder* as replacing *port helm* and *left rudder* as replacing *starboard helm*. The older terms are still in use elsewhere throughout the world (by pilots for example) and naval officers must be familiar with them. Where these older terms occur in the text of this and subsequent chapters, the corresponding new term is given in a note

1. The ordinary direct influence of the Rudder.

2. The Screw Current,—which we shall find to be made up of two distinct parts.

3. The Force exerted by the revolving blades of the Screw to drive the stern to one side or the other by their direct Sidewise Pressure upon the water.

4. The Wake Current.

1. The Rudder.—The effect of this is simple and well understood. It calls for no explanation here, except in so far as it is complicated by the screw current, in connection with which it will be fully treated below.

2. The Screw Current.—As the screw turns, it draws in a current from one direction and forces it out in the other. In going ahead, the current is drawn in from forward and forced out aft. In backing, it is drawn in from aft and forced out forward.

It is found that the in-rushing "suction" current may be considered as flowing parallel to the line of the shaft, but that the current driven off from the screw partakes to an important degree of the rotary motion of the blades and moves diagonally to the shaft and keel.

(a) If the screw is turning ahead, the inflowing suction current from forward moves along the lines of the run toward the screw and has no appreciable effect upon the steering.

It is different with the outflowing current thrown off and driven aft by the screw. This current, by reason of the rotary motion which has been referred to, strikes diagonally upon the rudder-post and the rudder (which we will for the moment suppose to be amidships) and exerts a distinct force tending to throw the stern to one side. We must recognize here, however, two factors opposing each other. The upper blades of our right-handed screw move over from port to starboard and drive their current against the port upper side of the rudder-post and rudder. At the same time, the lower blades drive in their current upon the starboard lower side. As the lower part of the rudder is commonly larger than the upper part, it is natural that the current from the lower blades, tending to drive the stern off to port, should more than overcome that from the upper blades, and that the resultant of these two forces should tend, upon the whole, to move the stern to port (in going ahead, with helm amidships). The conclusions of theory in this matter are confirmed by an

interesting experiment in which the rudder was divided into two parts by cutting it horizontally. With the two parts left free to move and the screw turning ahead (the ship being at rest), the upper part took up a position at an inclination of nearly 10° on one side of the keel, while the lower part stood at an equal angle on the other side. In other experiments, where the full rudder was left free to move under the influence of the screw current alone, it took a position at a small but distinct angle with the keel on the side toward which the current from the lower blades tended to deflect it.

If the rudder, instead of being kept amidships, is put over to one side, the sternward velocity of the current will have its effect, as well as the rotary velocity.

With the ship and screw both going ahead, this part of the current will add its effect to the ordinary steering effect of the rudder, and simply produce a greater turning force than would otherwise exist. It may happen, however, that the screw is moving ahead and sending its current aft against the forward side of a hard-over rudder, while the ship is moving astern and developing its ordinary effect upon the after side. This is the case when a ship, while moving astern with some velocity, suddenly puts her helm hard over and throws her engines full speed ahead. This case, which is one of special importance, will be treated at considerable length in a later section.

(b) *If the screw is backing*, it draws in a current from aft and forces it out forward, where it strikes against the sides of the afterbody with the diagonal velocity given by the rotary motion of the blades. In this case, the "suction" current, coming from aft, will have no effect as long as the rudder is amidships, since its motion is parallel to the keel; but if the helm be put over to either side, this current assumes great importance and may even become the controlling factor in the steering of the ship. So long as the ship is moving astern, this factor acts with the ordinary resistance of the water and simply increases the rudder's turning power. But in the case where the engines are suddenly backed while the ship has headway, this "suction" current opposes and reduces the natural steering power of the rudder, and may altogether overcome it and throw the ship's head to the opposite side from that to which the rudder would throw it under ordinary conditions. This case is the converse of that described under (a) and is one of the most important

with which we shall have to deal in the later sections of this chapter.

We have now to consider the effect of that part of the screw current which, in backing, is thrown off from the screw and driven forward against the afterbody of the ship. Since this current partakes of the rotary motion of the screw, it will strike the stern at a considerable angle to the keel line and will produce a pressure tending to force the stern off toward the side to which the blades are moving. It is clear that the upper blades of our right-handed screw will be moving over from starboard to port and sending their current against the upper starboard side of the stern, while the lower ones send theirs against the port side in the neighborhood of the keel. We have thus two forces acting against each other; but a little consideration of the shape of the stern and the position of the screw will make it clear that the upper blades are much more favorably situated than the lower ones, so far as this effect is concerned, and that we may fairly expect their current to prevail over that from the lower ones. Not only are they closer to the body of the stern, but they drive their current against it at a much more effective angle, owing to the fullness of the upper, as compared with the lower, run. We might then expect that the effect of this part of the screw current would be, upon the whole, to force the stern to port; and this is found to be the case in practice.

If the helm be kept amidships, so that the effect of the rudder is eliminated, the stern of a right-handed screw steamer, in backing, works off to port. It does not follow that this is entirely due to the screw current, for we shall find that the factor we are next to consider—the sidewise pressure of the blades—may have much to do with it; but experiments show that the screw current is an important factor in the matter and that its action is as above described.

3. The Sidewise Pressure of the Screw Blades.—As the blades revolve, they exert a force tending to drive the stern off to the side opposite that toward which they are moving. Since the upper and lower blades move toward opposite sides, we have here two forces acting against each other which would exactly balance but for the fact that the lower blades, moving under greater pressure than the upper ones, meet with greater resistance and exert a greater force. The result is that the

pressure of the lower blades preponderates; and in any given case, the stern tends, so far as this element is concerned, to work off to the side from which the lower blades are moving. In going ahead, then, the tendency of the stern is to starboard, whereas in backing, it is to port.

It is found that this factor is not of great practical importance under ordinary circumstances, but that it becomes so whenever, from imperfect immersion or from any other cause, the upper blades "churn" the surface water. It is a fact of every day observation that when a steamer is starting from rest, either going ahead or backing, the screw, even though well immersed, usually "churns" more or less until the ship has gathered way. Under these circumstances, therefore, this factor has maximum effect. Its effect is also important even when the ship has way, if the upper blades are only partially immersed. The fact that it does not count when the ship has headway and when the screw is well immersed is due to the factor which we have next to consider.

4. The Wake Current.—This is a current which the ship carries with her as she moves ahead through the water, by reason of the friction between the water and the hull. The body of water involved in it extends to a considerable distance on either side, but attains its maximum volume and velocity immediately under the stern; that is to say, in the vicinity of the screw and the rudder, where it breaks up the water, and, by its forward velocity, materially adds to the pressure on the upper blades of the screw. It is essentially a surface current, and experiments show that it decreases as the depth of water increases and that, at the level of the keel, it is practically imperceptible.

It is difficult to assign any definite value to the velocity of this current, but it has been assumed in certain investigations by Professor Rankine at 10 per cent of the speed of the ship. It enters into our problem only in cases where the ship is moving ahead.

The effect of the wake current upon the rudder is to reduce the steering power. Its effect upon the screw is to increase the resistance to be overcome by the upper blades, and thus to offset the advantage of the lower blades in direct turning effect due to the greater depth in which these blades move.

We proceed now to consider the effect of the elements which have been described, upon the behavior of a steamer under various conditions.

Turning Curves for Ships of Different Lengths and Characteristics.

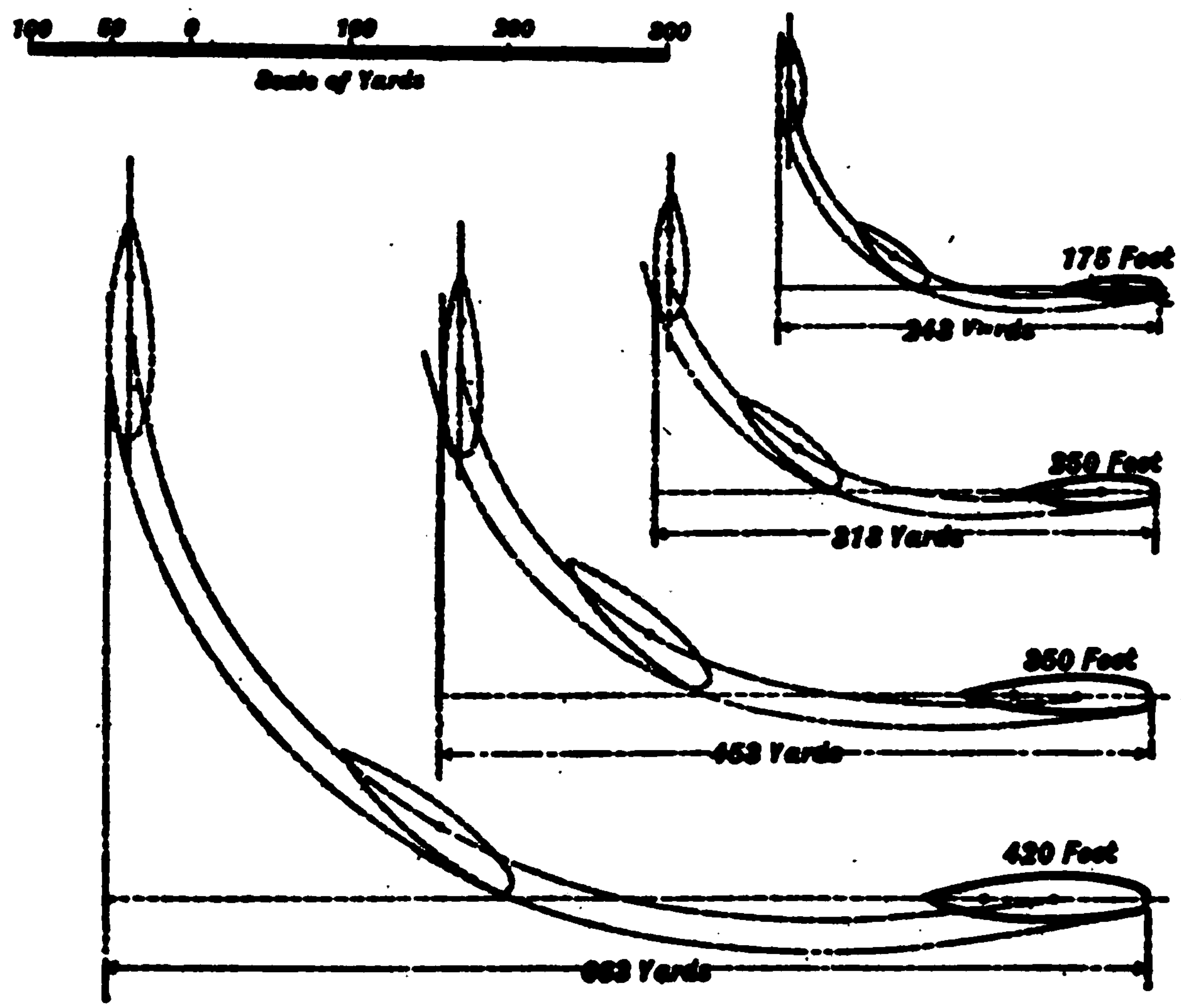


Fig. 1

Turning Curve for Ship of Medium Length and Average Characteristics (Length 320 Feet.)

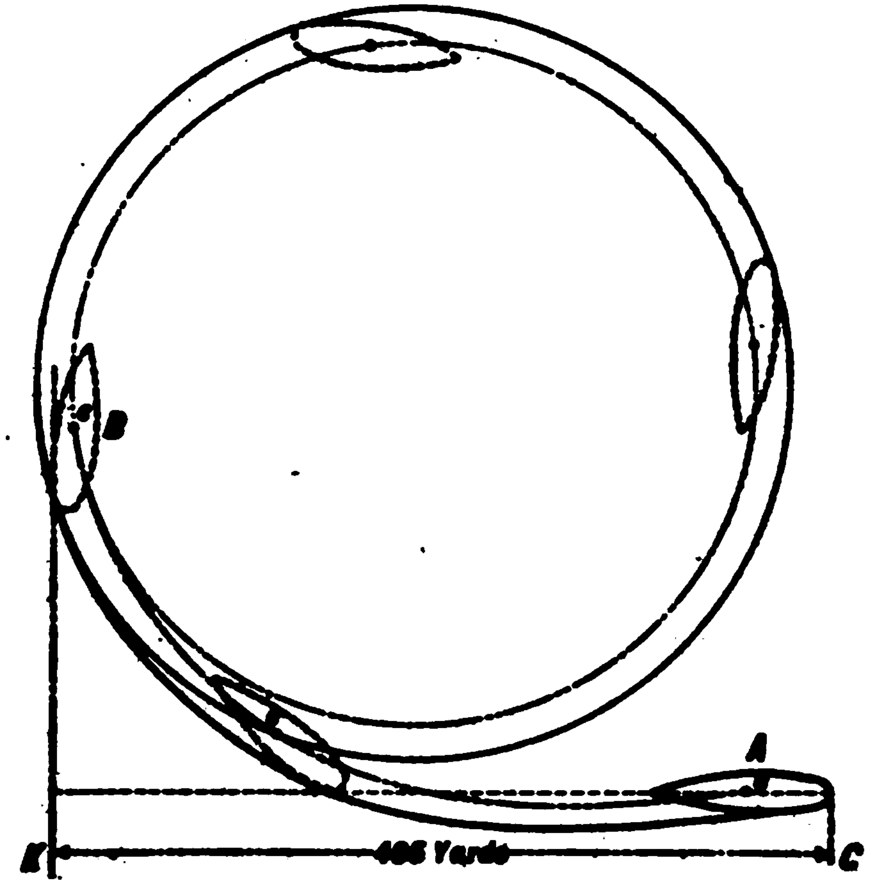


Fig. 2

TURNING CURVES.

This subject will be treated under the following heads:

1. Ship and Screw going Ahead.
2. Ship and Screw going Astern.
3. Ship going Ahead, Screw Backing.
4. Ship going Astern, Screw going Ahead.

§ II.

SHIP AND SCREW GOING AHEAD.

Here the rudder is the great controlling factor, and the problem of manœuvring under these conditions may be treated practically with very little reference to the effects of the screw. It would not be exact to say that these effects are wholly inappreciable, for there are conditions under which they become clearly apparent; but they are rarely important and it would be almost impossible to lay down satisfactory rules with regard to them. All that need be said of them may be summarized as follows:

If the helm is kept amidships, the screw has a slight tendency to throw the head to port while the ship is gathering way and moving slowly ahead. As the speed increases, this tendency gradually disappears and at medium speeds the screw seems to have no steering effect whatever. Finally, at high speeds, there seems to be with some ships a slight tendency of the head to starboard.

If the helm is put over to either side while the screw is turning but before the ship has gathered way, the discharge current from the screw exerts a powerful steering effect, driving the stern off exactly as if the ship were moving ahead; and this effect continues in a gradually decreasing degree as the ship gathers way and works up to the speed which is properly due to the revolutions of the screw at the time. Thus, if the helm is put to port[1] and the screw started ahead with a number of revolutions corresponding normally to a speed of ten knots, the head will turn at once to starboard, as if the ship were moving. As the ship gathers way, the steering effect of the screw gradually falls off and is replaced by the normal steering effect of the rudder for headway. We may put this differently by saying that the steering effect of screw current is due to the "slip" of the screw.

We proceed to consider the steering of a ship when steaming ahead, as affected by the rudder alone; beginning with the case

1. right rudder.

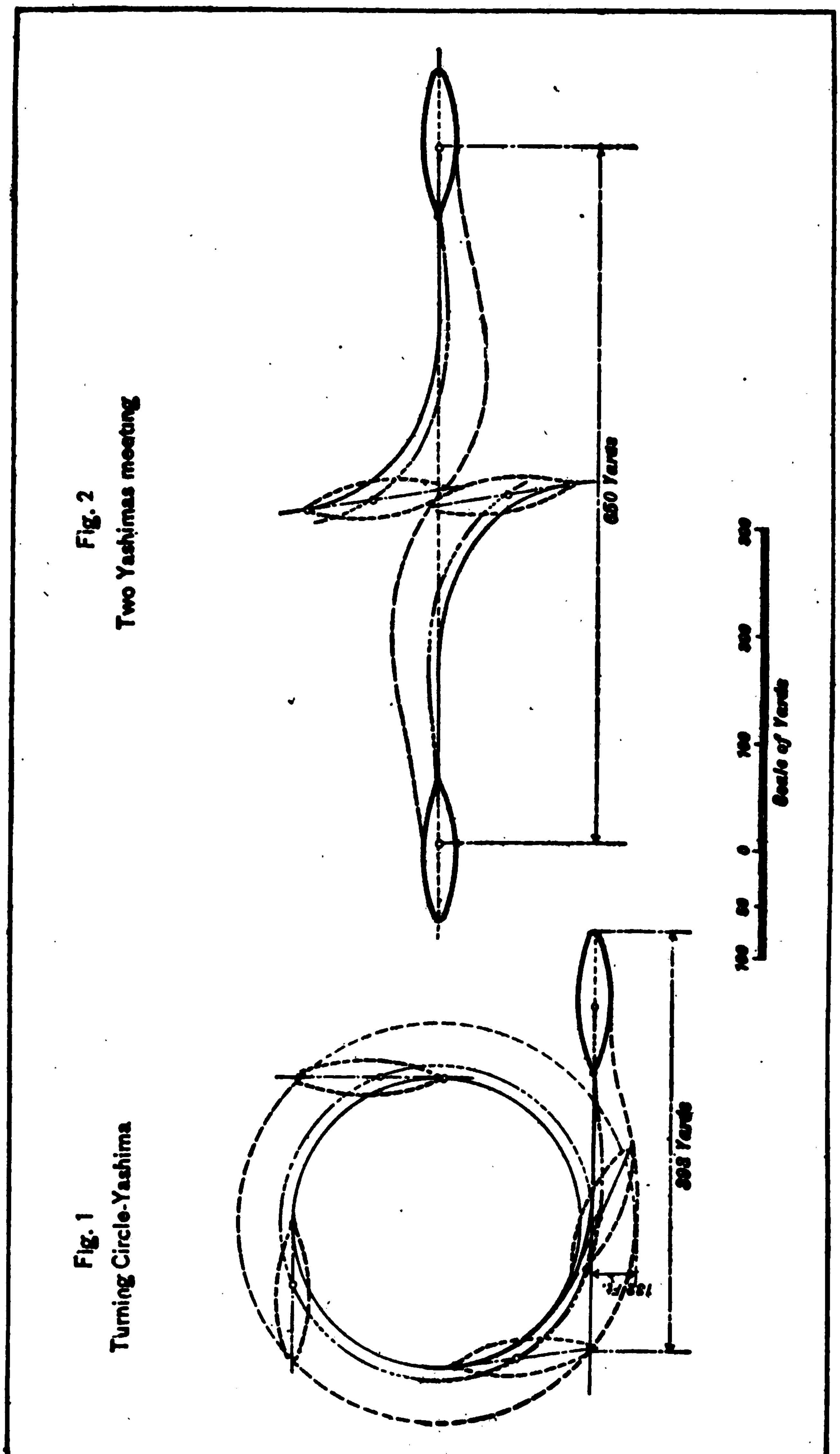
in which the ship, while running at fair speed, puts the helm suddenly hard over, without reversing or stopping the engines. This case presents certain points the examination of which will be helpful in dealing with other cases to be taken up later.

In Plate **93** are shown the curves traced out in this way by a number of ships of widely different types. Some of these ships had twin-screws, but it is found that so long as both screws are kept turning ahead, there is no important difference between the curve of a single screw and that of a twin-screw ship.

Observe that not only does a short ship turn in a shorter absolute space, but she turns also in a smaller number of ship's lengths. Thus for a ship 100 feet long, the "advance" will be approximately 3½ lengths (350 feet) while for one 500 feet long it will be more nearly 4½ lengths = 2250 feet.

From these and other curves too numerous to be reproduced here, a curve has been constructed for such an average ship as the one to which we are at present confining our attention. Fig. 2, Plate **93**. It is clear that the differences between this and the individual curves from which it has been derived are very slight and are all differences of degree, not of kind. The following discussion of this curve may therefore be accepted as practically exact for all ordinary types of ships.

It will be noted that, the helm being put hard over as rapidly as possible (position A), the ship begins to turn at once and turns with increasing rapidity up to about the point B, from which point onward she turns uniformly in a path which is practically a circle. As she swings around the circle, her bow points steadily inward while her stern sweeps out a circle considerably larger than that traced by her bow. She does not, that is to say, follow her own keel line, but presents her bow and side to the water through which she moves. To this statement, however, some qualification must be made, since there is one point of the ship which does, at every part of the circle, follow the line along which the keel is pointing at that part. This is called the "Pivoting Point." It is the point about which the ship turns, as viewed by an observer on board. Its position depends upon the speed and the manœuvring power of the ship. When these are exceptionally high, it is well up toward the stem, and it may even be outside and ahead of the ship, on the keel line prolonged.



TURNING CURVES OF YASHIMA.

In our average ship, we may take it about one-quarter the length of the ship from the stem.[1]

An analysis of the curve brings out the following points:

1st. The first effect of putting the helm over is to throw the whole mass of the ship off to leeward, so to speak; that is to say, to the side opposite that toward which it is desired to gain ground.

The stern goes off most; but the whole ship, except the extreme bow, is thrown more or less to this side, and some experiments have seemed to show that even the bow goes off at first. This throw of the stern to leeward is technically the "*kick*."

2nd. The ship ranges ahead nearly along the line of her original course, but slightly to leeward of it, for a distance which may be roughly stated as from two to three ship's lengths, before she commences to gain ground in the desired direction.

> The momentum of the ship along her original course persists for a time and drives her on along this line in spite of the forces which are turning her head away from it.

3rd. The stern does not finally clear the line of the original course until it has covered from two to three lengths measured along that line. In the meantime, the ship's head has changed by more than three points.

4th. If this manœuvre were resorted to for the purpose of avoiding a danger suddenly discovered dead ahead and distant from two to three ships' lengths, it would probably be ineffectual.

5th. The distance covered parallel to the original course from the time of putting the helm down until the ship has turned through eight points, is in this case approximately four lengths. This is called the "*Advance*" and in the figure is represented by the distance C K (Fig. 2, Plate 93).

All of the above points are brought out in a very striking way in the curve of the Yashima—a ship of altogether exceptional manœuvring power and of high speed (Fig. 1, Plate 94).

[1] It is doubtless true, as pointed out by Admiral Colomb and others, that the pivoting point changes its position in the early part of the turn and does not settle down as a fixed point until the ship's path has become a true circle. The variation, however, is not important for our present purpose

The characteristics which have been noted in the other curves are all present here in an exaggerated form. It will be seen that if two Yashimas, sighting each other dead ahead, should put their helms hard aport[1] while separated by a distance of 650 yards (5 ships' lengths) their sterns would collide (Fig. 2, Plate 94).

The remarkable manœuvring power of the Yashima is due to the fact that her after deadwood is cut away to a very unusual extent. This reduces the resistance of her afterbody to lateral motion, and as a result the stern is thrown off much more rapidly and to a greater distance than would ordinarily be the case. This illustrates very strikingly the fact that it is the stern and not the bow of the ship that moves in turning.

With regard to the speed involved in these curves, this begins to fall off, as might be expected, the moment the helm is put down, the reduction being due to the resistance of the rudder and the sidewise motion of the ship. It continues to fall off until the point is reached where the turning curve becomes uniform and circular, at which point it has fallen off to something like 60 per cent of its original value. From this time on, it remains constant as long as the turn continues with the same helm angle.

It is found that the speed at which a ship is moving when her helm is put over does not greatly affect the space in which she will turn. A ship running at eight knots speed, putting her helm down suddenly, follows very nearly the same track as if she were running at twelve knots. This is a result which would perhaps hardly have been anticipated, but it has been demonstrated by too many experiments to be called in question. As regards the *time* of turning, there is, of course, a great difference in favor of high speed.

It follows that if a ship is attempting to clear a stationary object by putting her helm hard over, it makes little difference with regard to her success whether she slows or continues at full speed, though it will make much difference in the force with which she strikes, if strike she must. If the object to be avoided is another ship under way, there will be an advantage in gaining time by slowing, as this will give an opportunity for both ships to recognize the situation clearly and to act accordingly. It is important to remember, moreover, that *during the time actually occupied in putting the helm over*, a steamer running at high speed will cover a greater distance than if she were running slow.

1. rudders full right.

We do not here deal with the question of reversing the engines. This will be considered in a later section.

We have thus far confined our attention to the effects of a helm put suddenly hard over. This is an exceptional case, but it brings out very clearly the points that are involved in the more common case in which a small angle of helm is used—generally for a short time only—and a small change of course effected. In this case, also, the stern is thrown off, and for some time the body of the ship moves along a line to leeward of the original course. This should always be taken into account. It becomes of great importance when manœuvring in crowded waters, and in all cases where the danger to be avoided is close aboard. *The realization that the stern moves and not the bow, will often make all the difference between a close shave and an inevitable disaster.*

We have seen that the effect of speed upon the space in which a ship will turn with a given angle of helm is not great. It should, however, be remarked, that a fair speed is essential for the proper handling of any ship. Not only is a ship when moving very slowly through the water at the mercy of the wind and sea and tide, which under such circumstances have an undue effect upon her, but all the varying and conflicting elements that have been described in § I are liable to manifest themselves in unexpected and seemingly erratic ways. It is therefore important always to keep up a reasonable speed; and while this term is hardly susceptible of exact definition, it will probably be agreed that such a ship as we are at present considering—of average size and manœuvring powers—will not handle with certainty at speeds much below four knots.

We shall discuss in another chapter the theory held by many seamen, that it is safer to run at maximum speed through a fog than to slow down.

Although it is found, as has been explained, that when a ship is going ahead, the rudder so far outweighs all other elements involved in the steering that these other elements may in general be neglected, it is nevertheless true that hardly any ship turns with exactly the same readiness to port and to starboard; and it appears from experiments to determine the tactical diameter of men-of-war that the circle made with port helm[2] may differ from that with starboard helm,[1] by as much as ten per cent.

Although we are dealing at present with the *turning* of ships, it may be well to add a word with regard to the power of *stopping*.

1. right rudder. 2. left rudder.

It is found that a ship steaming ahead with the helm amidships, and suddenly reversing her engines without moving the helm, will stop in from three to five times her own length; and that this distance is practically independent of the size and speed of the ship.

This supposes the same power used in backing as in going ahead. If there is a reserve of power available for backing, a ship should be stopped in twice her length.

The space in which a ship can be stopped, as compared with that in which she can be turned, becomes important when danger is suddenly discovered ahead and on both bows; as, for example, when a ship finds herself heading for a coast or a line of reefs, and dangerously close. We have seen that she may, by putting her helm hard over, turn through eight points with an "*advance*" in the direction of the original course, of about four lengths. This would seem to show that it is at least as safe to try to clear such a danger by means of the helm, as by stopping the ship.

This was the conclusion of the Committee of the British Association (see Report British Association 1878, page 422).

It will be shown later that probably the safest course of all is to combine both methods, putting the helm hard over (preferably to port), and when the head has begun to swing decidedly, reversing full speed and immediately *afterward* shifting the helm.

The time and space in which a ship may be brought to rest when moving at a given speed are matters of great practical importance. The time may be determined by the very simple experiment of reversing the engines and noting the number of seconds required to come to rest. Observations upon the space are not so easily made, but experience shows that the space may be determined with considerable accuracy from the observed time, by the simple formula:

$$D = 7/10\ ST.$$

Where $D =$ Distance in feet required to stop.
$S =$ Speed in knots and tenths.
$T =$ Time in seconds (observed).

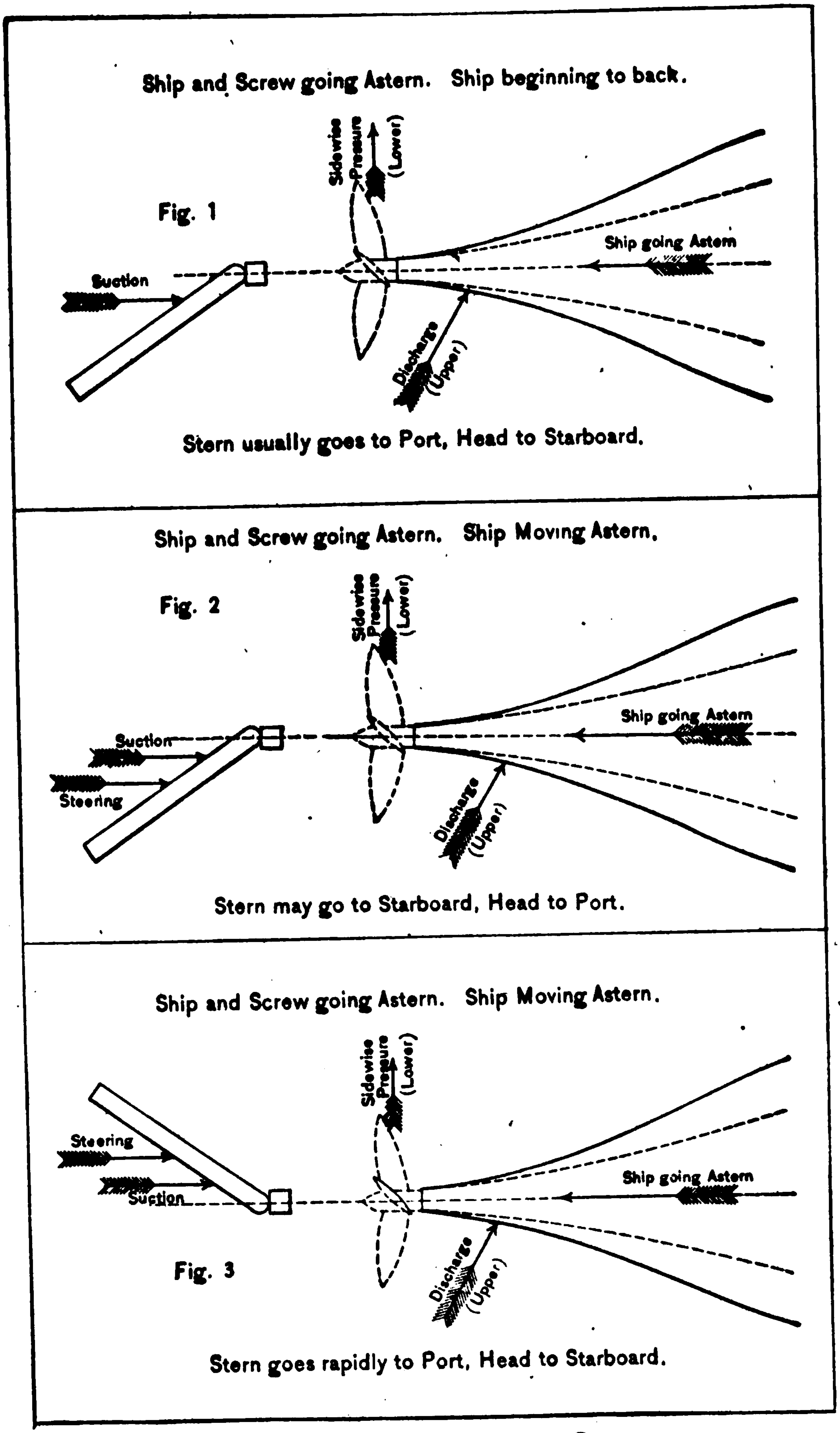
See "General Information Series No. IX," issued by Office of Naval Intelligence, U. S. Navy Department.

§ III.

SHIP AND SCREW GOING ASTERN.

(Plate 95.)

This case is more complicated than the preceding one, for the reason that the effects of the screw, which in going ahead are so



EFFECTS OF SCREW UPON STEERING.

far overpowered by those of the rudder that they may usually be neglected, become, in backing, quite as important as those of the rudder, and in many cases much more important.

The forces involved in the steering of a steamer in backing are:

1. The Sidewise Pressure of the Blades, driving the stern to *port*.

2. The "Discharge" current, thrown forward and inward from the screw, against the sides of the run, and tending also to drive the stern to *port*.

3. The "Suction" current, drawn in from aft against the after side of the rudder, and acting to throw the stern to starboard or to port according to the way the helm is put. This factor does not enter into the problem with the helm amidships.

4. The ordinary steering effect of the rudder, tending to throw the stern toward the side opposite that to which the helm is put. This factor does not enter into the problem with the helm amidships.

3 and 4 above are closely related and act together, but 4 is dependent upon the motion of the ship through the water, while 3 is independent of this motion and connected only with the action of the screw. For this reason, we must distinguish between the case in which the ship is just starting astern from rest, and that in which she is moving astern with considerable velocity. In the first case we may ignore 4, while in the other we must consider it. In both cases, we shall find an inclination for the stern to back to port, due to the fact that 1 and 2 always act in that direction, while 3 and 4 act with or against them according as the helm is put to starboard or to port.

(a) If the ship is just beginning to back, 4 may be neglected, and 3 will tend to drive the stern to the side opposite that to which the helm is put. If, then, the helm is a-starboard, 3 will act with 1 and 2, and the tendency to port will be very marked. If the helm is aport, 3 will oppose 1 and 2, but will not usually overcome them; and the tendency of the stern to port though very much reduced, will still exist. In other words, a steamer just beginning to back from rest will in general throw her stern to port even against a hard-over port helm.[1]

(b) As the ship gathers speed astern, 4, the steering effect of the rudder, becomes of greater and greater importance. It always acts with the suction current (3) upon the after side of the rudder; and if the helm is put to port, these two

1. right rudder.

forces (3 and 4) may ultimately overcome 1 and 2 and give the stern a slight tendency to starboard. If, on the other hand, the helm is put to starboard, all four of the forces involved act together and throw the stern rapidly to port.

It results from the above, that when a ship is beginning to back but has not yet gathered decided stern-board, it is difficult, if not impossible, to prevent her stern from working off to port; and that after she has gathered considerable speed astern, she will still have a decided inclination to back to port, but may usually be made to back to starboard by hard-over port helm.

If it is desired to back as nearly straight as possible, the helm must be put hard aport.

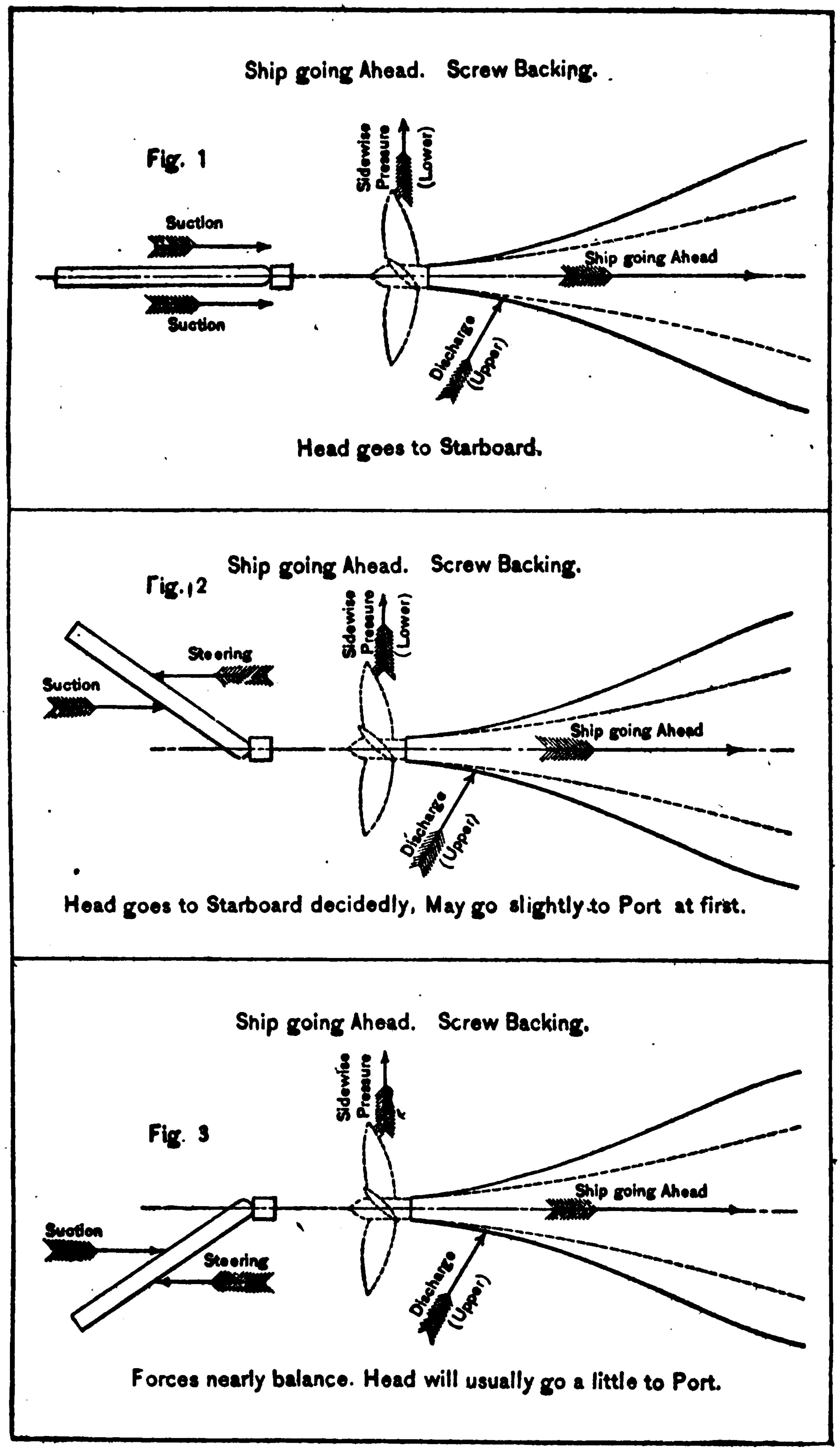
The effect of a breeze is not great upon a vessel moving slowly astern, but becomes important as the speed increases; so much so that, with a moderate breeze, a vessel going astern at a speed of three knots or more will back up into the wind in spite of all that can be done to prevent it. It follows that, in spite of the tendency to port which has been insisted upon above, a ship may be backed to starboard, if the breeze is from that side, provided that the circumstances admit of going astern for some time and at fair speed. It follows, also, that if it is desired to back to port while the breeze is from the starboard side, the more slowly we go astern the better, and if the breeze is fresh, it will probably be impossible to avoid backing into it.

Generally speaking, a ship is backed only when working alongside a dock or into a slip, or when manœuvring in crowded waters; conditions which do not admit of backing for a long time or at any considerable speed; and under these circumstances, it is desirable to plan all manœuvres in such a way as shall involve the throwing of the stern to port in backing.

§ IV.

SHIP GOING AHEAD. SCREW BACKING.

This is in some respects the most important case with which we have to deal, for the reason that it is the one most frequently connected with the emergency of danger suddenly discovered and close aboard. The cause of many collisions can be traced to a widespread ignorance of the rules which govern the steering when the engines are suddenly reversed while the ship is going ahead. Yet these rules are simple and have been stated many times.



EFFECTS OF SCREW UPON STEERING.

It is assumed, naturally enough, by those who have not studied the many practical experiments which have been made in connection with this matter, that so long as the ship has headway she will continue to obey her helm in the usual way, even though the screw is backing and gradually reducing her speed.

This is so far from being the case, that in many instances exactly the opposite occurs; the matter being complicated, from the instant the engines are reversed, by the "screw current" which has been described in § I as being drawn in against the after side of the rudder and driven forward against the afterbody of the ship.

The forces involved in the steering under these conditions are the following:

1. The direct steering effect of the rudder, tending, as in all cases of headway, to throw the stern toward the side to which the helm is put.

2. The "Suction" current, drawn in from aft by the screw, against the after side of the rudder, and forcing the stern toward the side opposite that to which the helm is put.

3. The "Discharge" current driven forward and inward against the stern, forcing the stern to port, without reference to the helm.

4. The Sidewise Pressure of the blades, also forcing the stern to port, without reference to the helm.

(Plate 96.)

We have here a number of conflicting elements, the final result of whose action it would be useless to attempt to predict from theoretical considerations. Since, however, there are two of them which always act to throw the head to starboard, we may be sure, at least, that the ship will turn much more readily to that side than to the other.

We proceed now to consider the matter from the point of view of practice, and we are fortunate in having the result of several very complete series of experiments, from which to draw our conclusions.

In 1875, Professor Osborne Reynolds communicated to the British Association for the Advancement of Science, the results of certain experiments made with models for the purpose of determining the effect of the screw upon the steering of steamers; and for several years after this time, he was engaged, as Secretary of a committee appointed by the Association, in experiments and

investigations upon the same subject. The reports of this Committee are to be found in the Proceedings of the Association for 1876, 1877, and 1878.

Since these reports were made, much additional evidence has become available, and it is now possible to lay down fairly definite laws with regard to the behavior of ships under the circumstances we are now considering, although it must never be forgotten that exceptional conditions, especially of weather and of the draft and trim of a ship, may modify all such laws in ways which can only be foreseen by an officer thoroughly familiar with the peculiarities of his ship and her temporary condition as regards draft and trim.

The following rules will usually be found to hold for our right-handed screw steamer, of average characteristics, when the engines are suddenly reversed from full speed ahead to full speed astern.

(a) **The helm kept amidships.**

The head will fall off to the starboard, and the ship will gain ground to the right before losing her way. The stern will, in the beginning, go off slightly to the left, and the mass of the ship will range along the line of the original course or a little to the left of it (Fig. 1, Plate **96**).

(b) **The helm put hard a-starboard[2] at the same instant that the engines are reversed.**

The head will usually go to port at first, but neither very rapidly nor very far; it will then begin to swing to starboard and will fall off more or less to that side. The ship will gain ground to the right of her original course, before losing way (Fig. 2, Plate **96**).

(c) **The helm put hard aport[1] at the same instant that the engines are reversed.**

The head will at first go to starboard and may in some cases persist in swinging to that side, though not nearly so fast or so far as in (b). In a majority of cases, after swinging somewhat to starboard, it will stop and swing slowly back to port, and the ship will come to rest with her head from one to two points to port of her original course. She will not gain ground materially to either side (Fig. 3, Plate **96**).

The more slowly the ship is moving ahead, and the faster the screw is backing, the more confidently may we expect her to behave as above described. The rules that have been given, and

1. right rudder. 2. left rudder.

indeed the whole preceding analysis, suppose the screw to be backed at full speed from the first instant, as it should be in all cases where certainty of manœuvring is important.

If the ship is running slowly, but with a reserve of power immediately available for backing at high speed (as should always be the case in a fog), the rules which have been laid down may be relied upon with especial confidence, since they are based upon the power of the backing screw to overcome the steering effect of the rudder due to the speed of the ship. So in the other important case of turning or manœuvring in a limited space or working alongside a dock, where the power available for backing will always be great in proportion to the speed of the ship.

If, on the other hand, while the ship is moving ahead at high speed, the engines should be reversed with only half power, the ship would unquestionably obey her helm for headway; a port helm[1] throwing her head to starboard in spite of the slowly backing screw.

The case with which this section has chiefly dealt—that in which the screw is backed with power equal to or greater than that corresponding to the speed of the ship—is the ordinary case of practical seamanship, covering both the situation where the screw is backed for manœuvring a ship in harbor, and that where it is suddenly reversed when going ahead at some speed, to avoid danger suddenly discovered.

As the whole question herein dealt with is one of opposition between the steering effect of the rudder due to the speed of the ship and the steering effect due to the screw current, it will be easily understood that there may be cases in which the balance of these forces will be different from that which is here described for "average" conditions, and in which, accordingly, the behavior of the ship will differ from that described. But while we may admit that in some cases a ship backing her screw with full power will still obey her helm for headway, it must be insisted none the less strongly that the screw current will have a powerful effect in the direction herein described and that if the ship obeys her helm for headway it will be with greatly lessened effect.

The *time* of putting over the helm exercises an important influence upon the behavior of the ship. If it is put over before reversing the engines, the ship's head will of course commence to swing in direct obedience to it (for headway), and the screw cannot be expected to overcome this and to produce the same effect

1. right rudder.

as if it were reversed simultaneously with the putting over of the helm.

If the ship has actually begun to swing in obedience to a hard-over helm before the screw is reversed, she will in most cases continue to swing the same way in spite of the screw, although much less rapidly than if the screw were not reversed.

If, on the other hand, the engines are reversed before the helm is put over, then the rules laid down above are emphasized; and it should be noted that the helm can be put over more rapidly after the screw is reversed than before. This may be a very important point with ships steering by hand-power.

It is probable that some ships will, for a very short time, continue to obey the helm as for headway, even though the helm is put over at the same time that the screw is reversed; but as they will shortly begin to act in accordance with the above rules, there are very few cases in which we can run into any danger by considering the rules to hold.

We may usually remove all question with regard to the movement of the ship by putting the helm to one side before reversing the screw, *thus getting a swing on the ship in the desired direction*, then reversing the screw, and following this up by reversing the helm. Suppose, for example, we wish to throw the head to starboard. We stop the engines and put the helm hard aport,[1] and when the head has begun to swing to starboard, reverse the engines and immediately shift the helm to hard a-starboard.[2] If we wish to turn to port, we stop, put the helm a-starboard, and wait a little longer than in the preceding case—(since the head does not turn to port as easily as to starboard with engines backing)—then throw the engines to full speed astern and follow this by putting the helm hard aport.[1] By this means we shall remove all doubt about casting to port, although the turn to that side will be made slowly, even under these conditions.

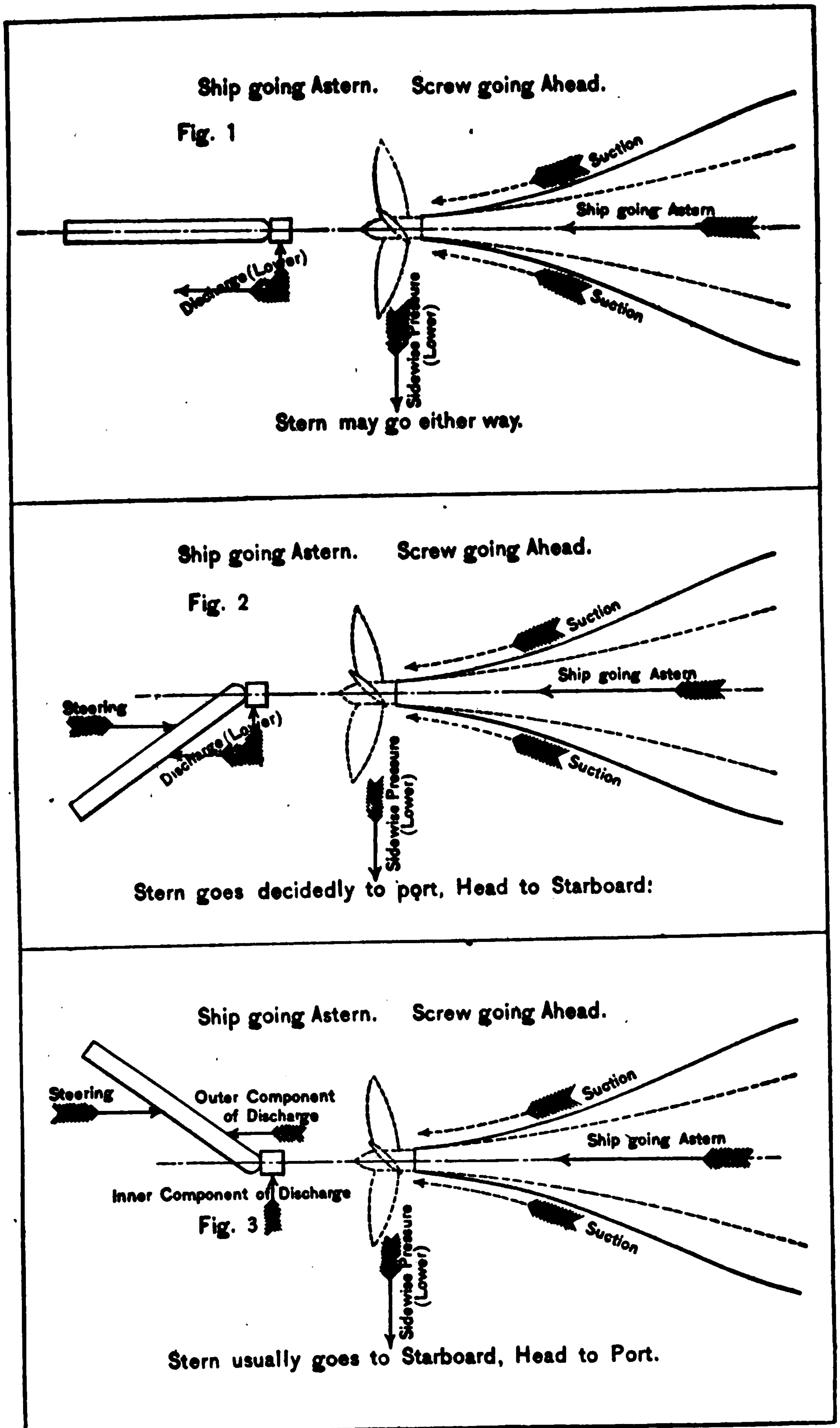
The rules laid down above are summarized in the statement that, in general, a ship tends to obey her helm with reference to the way the *screw* is moving, not with reference to the way the *ship* is moving.

§ V.

SHIP GOING ASTERN. SCREW GOING AHEAD.

This case closely resembles the preceding one and is subject to the same general law; viz., the ship obeys her helm with

1. right rudder. 2. left rudder.



EFFECTS OF SCREW UPON STEERING

reference to the motion of the screw, not the motion of the ship.

The forces involved in the steering are:

1. The direct Steering effect of the Rudder due to sternboard, acting to starboard or to port according to the way the helm is put.

2. The Sidewise Pressure of the Blades, acting to drive the stern to starboard.

3. The Discharge Current thrown off by the screw, and consisting of two components; (a) acting directly astern, and (b) acting inward against the starboard side of the rudder post and tending always to force the stern to port.

If the helm is amidships, 1 and 3 (a) are eliminated from the problem, and only 2 and 3 (b) are to be considered. These two oppose each other, and it is impossible to foresee, in any given case, which one will prevail (Fig. 1, Plate **97**).

If the helm is aport we shall have 1 and 2 forcing the stern to starboard, and opposed by both components of 3 (Fig. 2, Plate **97**).

It is found in practice that, under these conditions, the effect of 3 greatly exceeds that of the other factors, and that the stern goes off decidedly to port.

If the helm is a-starboard, we have 2 acting as before to force the stern to starboard, and assisted now by 3 (a), while 3 (b) acts with 1, to force it to port. In practice, the forces acting to starboard commonly prevail, and the stern goes to that side (Fig. 3, Plate **97**).

A comparison of the figures illustrating this case will show that 1 and 3 (a) are in every instance opposed to each other, as are also 2 and 3 (b). Of these forces, 1 and 3 (a) are by far the most important, and the course of the ship is usually determined by their relative values.

It is found in practice that, as a general rule, 3 (a) (the screw current acting against the forward side of the rudder), overpowers 1 (the resistance of the water on the after side), and, as already stated, the ship obeys her helm with reference to the motion of the screw, not of the ship. This assumes that the sternward velocity of the ship is not great, and that the screw is turning ahead full speed—the usual conditions when manœuvring in this way. If the opposite conditions exist, that is to say, if the ship is moving rapidly astern and the engines are turning slowly ahead,

it may be found that the natural steering power of the rudder will overcome the feeble screw current, and that the ship will obey her helm as in ordinary cases of sternboard.

The resemblance between the case described in the present section and that dealt with in § IV is very close, but one important difference should be noted. The *discharge* current driven aft when the screw goes ahead is more directly localized in its effect upon the rudder than is the *suction* current which is drawn in from aft by the screw when backing. While the suction current comes in a general way from abaft the screw and the rudder, only a part of it moves directly in line of the shaft, the remainder being sucked in from all sides more or less radially. The discharge current, on the other hand, although partaking to a certain extent of the radial motion of the blades, is localized upon the rudder as a distinct and powerful stream.

It results from this that the turning effect of the screw when the ship is going astern and the screw going ahead, is usually more pronounced than the corresponding effect when the ship is going ahead and the screw going astern.

§ VI.

TO TURN IN A LIMITED SPACE.

For reasons which have been already explained, it is difficult to turn a right-handed single screw steamer to port under any circumstances, where backing is necessary, and almost impossible to do so in a limited space. Under these conditions, therefore, the turn should, if possible, always be made to starboard, even if a little preliminary manœuvring is needed to place the ship in a position permitting this.

The ship being at rest, proceed as follows:

1st. Put the helm hard aport[1] and go ahead with the engines. The stern will swing off to port immediately. As she starts ahead, she will turn more and more rapidly. Allow her to gather as much way as is safe, and to forge ahead as far as space permits; then—

2nd. Reverse the engines full speed, and at the same time shift the helm to hard a-starboard.[2] The suction current against the after side of the rudder, assisted by the discharge current acting against the run, and by the pressure of the blades, will keep the stern swinging to port; and as she gathers sternboard (if allowed

1. right rudder. 2. left rudder.

Plate No. 98.

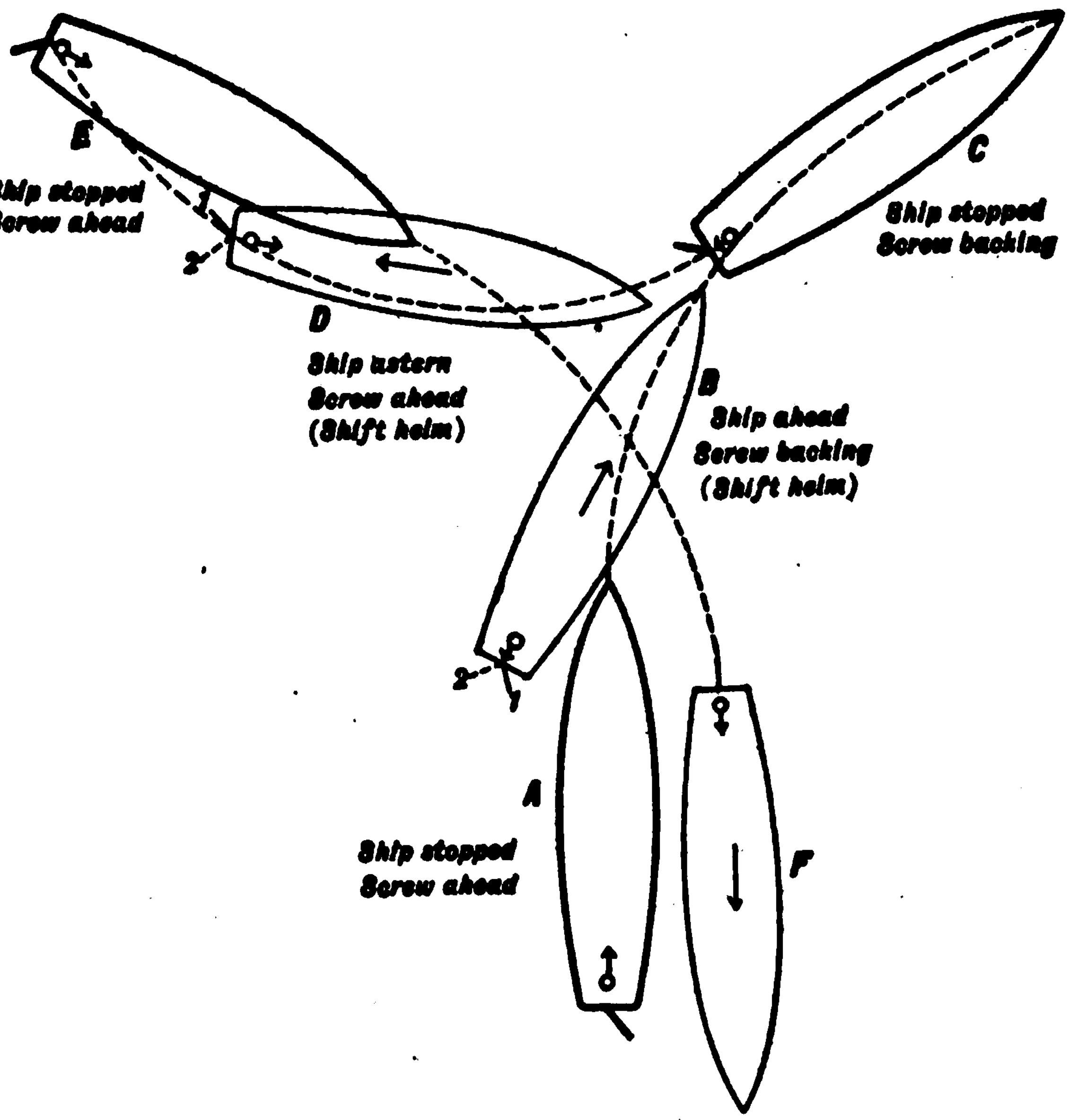


Fig. 1.

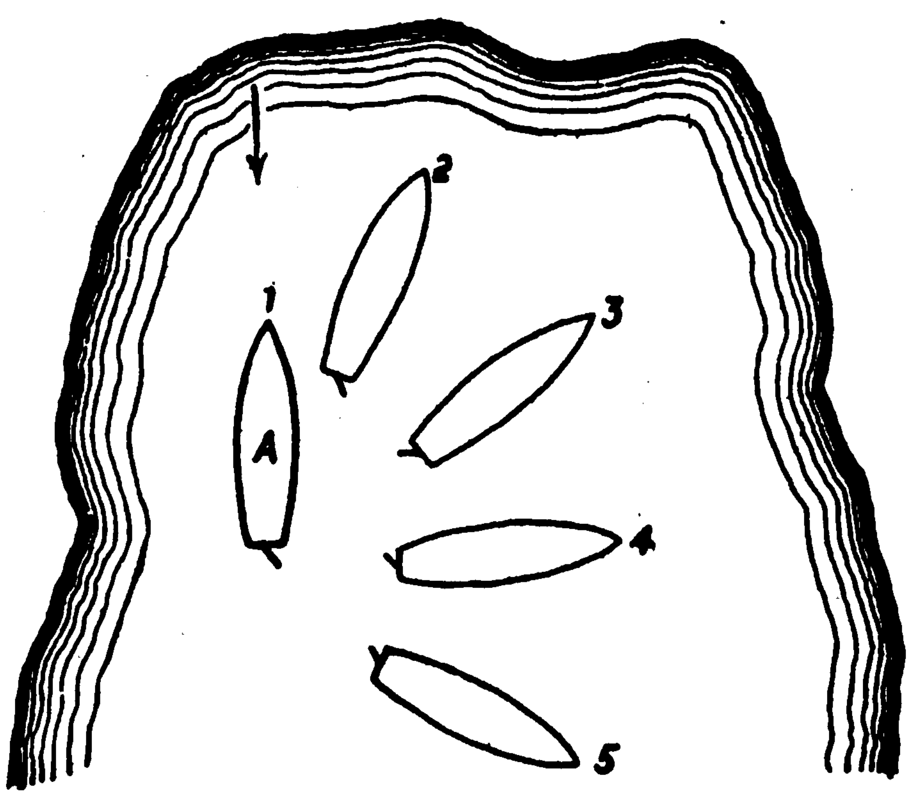


Fig. 2.

TURNING A STEAMER IN A LIMITED SPACE.
(SINGLE, RIGHT HANDED SCREW.)

to do so), the direct steering action of the rudder will help in the same direction.

Let her gather such sternboard as is safe, and back as far as space permits; then—

3rd. Go full speed ahead and shift the helm to hard aport. It is at this point that the most pronounced turning effect is to be anticipated. The whole power of the screw is producing a screw current and driving this current against the hard-over rudder.

4th. If necessary, continue going ahead and backing as above (Plate 98).

If more convenient to make a sternboard first, begin by backing with helm a-starboard.

If there is a fresh breeze on the *starboard* hand, avoid gathering any considerable sternboard, or she will back into the wind in spite of all that can be done. If the breeze is on the *port* hand, there will be an advantage in going astern as fast and as far as the surrounding dangers permit.

If the space, although limited, is sufficient to admit of going ahead and astern for a considerable distance and at fair speed, it will not be so difficult to turn to port, although the turn to starboard will always be more easily and rapidly made. Having decided to turn to port under these circumstances, stand well over to the right-hand side of the channel, and go ahead with hard-over starboard helm.[2] Having got good way on her, stop the engines and let her run. So long as she holds her headway, she will turn without difficulty.

Having run as far over as is safe, back the engines at full speed and put the helm aport. As she is starting to back from rest, or nearly so, she will probably throw her stern the wrong way. Continue backing hard in spite of this, and as she gathers speed astern the port helm will probably stop her turning the wrong way, and, if it does not turn her the right way, may at least hold her straight until you can afford to go ahead again. Then start the engines at full speed, put the helm a-starboard, and, as before, run as far as space permits. If necessary, back again, and repeat the tactics as above.

If there is any wind, it should be possible to gain some advantage here by the use of either jib or spanker; in fact, these sails can be used to advantage in nearly all cases of turning in a limited space. The spanker is especially useful as opposing the

2. left rudder.

tendency to back into the wind, in cases where this tendency is unfavorable for the manœuver to be performed.

If the tide is running out strong and setting you down toward danger, you should, in the early part of the turn, while heading more or less up stream, manage to gain ground against the tide while going ahead; and from the time when you have turned athwart and are beginning to throw the stern up stream, you should take on more sternboard (through the water) than you otherwise would, to hold her up against the current.

A vessel drifting in a current and making no way through the water will usually fall athwart and end by drifting broadside on. This may be a serious danger. In going through Hell Gate, for example, a steamer should never be allowed to lose headway, as she will be beyond control if she gets athwart. On the other hand there are cases in which, with a little space for working ahead and astern, this tendency might be utilized to make a turn which, without it, would be impossible.

A similar but still more pronounced tendency to fall athwart exists where a vessel which is making no way through the water is subjected to a breeze. A vessel so placed will almost always fall off and bring the wind abaft the beam. Advantage may often be taken of this fact to turn a ship in a space in which turning would otherwise be almost impossible. In Fig. 2, Plate 98, for example, *A,* wishing to get underway and stand out, weighs and cants his head a little to one side—preferably to starboard—if the screw is right-handed (Position 2). Then, with the engine stopped, he waits for the bow to fall off, under the influence of the wind, to Positions 3, 4, 5. At 5, the engines are backed and the stern swings up with the wind.

This manœuver is so simple, and applies to so many situations of turning in a limited space, that it is surprising how rarely it is used.

It often happens, where a current runs rapidly through a more or less narrow channel, that there is a perfectly marked eddy along the shore running in the opposite direction. This is the case in the East River, where, from the old Brooklyn Bridge to Corlear's Hook, an eddy current of considerable width runs up along the face of the New York docks while the ebb tide is running out with full force in mid-stream. A steamer coming down stream and having to turn to make a landing may run well over toward the Brooklyn side, then turn across with port helm,[1]

[1] right rudder.

ranging over and putting her bow in the eddy. In this way, she will turn with great ease. A similar phenomenon exists in the Mississippi at New Orleans, and ships may be turned there in the same way.

It is always worth while to post one's self upon such local peculiarities when likely to have occasion to deal with them.

§ VII.

TWIN SCREWS.

Twin screws have been used for many years, but did not come into general use, either for men-of-war or for merchant steamers, until about 1870, since which date they have been steadily growing in favor. Their advantages are to a great extent connected with the smaller size of screws required for a given power—this reduction in size over that of a single screw permitting large power to be utilized on a small draft, and preventing the racing of the screw as the ship pitches in a seaway. Moreover, the division of power between two screws and two sets of engines permits the use of smaller parts in the machinery, and especially in the shafts. This reduces the danger of flaws and of breaking in these parts, and minimizes the disastrous consequences if such breakage occurs; since a twin-screw ship with one shaft broken or one engine disabled is still perfectly under control and loses only a moderate percentage of her speed.

On the other hand, there is a certain weakness, which becomes important in a modern steamship with a fine run, in the great length of shafting, which, with twin screws, must project outside the ship, supported by struts from the hull (Plate **12**). There is also, no doubt, some danger of damage to the screws, which would not exist in a single screw, in entering and leaving docks.

The point in connection with twin screws with which seamanship is principally concerned, is the remarkable gain in manœuvring power which results from their use, and which is principally connected with the turning-leverage resulting from their position off of the midship line. It is clear that this must be very great in almost any case, though it will differ widely with different ships; being dependent, broadly speaking, upon the distance between the shafts at the center of gravity relatively to the length of the ship, and upon the angle at which the shafts are placed with each other.

In a ship of small beam as compared with her length, the shafts necessarily approach each other at a rather sharp angle; whereas with plenty of beam they can be kept nearly parallel and separated by a distance which gives a good turning moment.

In all cases where twin screws are used, one is right-handed and the other left-handed. In a great majority of cases the right-handed screw is placed to starboard and the left-handed screw to port, with the result that in going ahead the upper blades of each screw turn *outward*. This arrangement is sometimes reversed, the right-handed screw being placed to port and the left-handed screw to starboard, but the effect of this has been found so unfavorable to manœuvring power that it has been given up for new ships and is in many cases being removed from ships in which it has been already installed.

There is an indirect, but very important gain in *certainty* of manœuvring power, where twin screws are used, resulting from the more or less complete elimination from the problem of the rather baffling steering effects of a single screw. We must still take account to some extent of the current which is driven aft by each screw in going ahead, and drawn from aft in backing; but the axes of these currents will be well clear of the keel-line and will not materially affect the steering unless the helm is hard over, or nearly so. In the case in which the ship is moving rapidly in one direction and the engines are suddenly thrown the other way, these currents will greatly reduce the steering power of the rudder, but will not *reverse* it, as in the case of a single-screw ship. Similarly, in turning with one screw going ahead and the other backing (the ship having headway) the suction current from the backing screw reduces the steering power of the rudder but does not entirely overcome it.

The steering effect due to the sidewise pressure of the blades, which, as we have seen, is often a very important factor in the handling of a single-screw ship, disappears with twin screws when both screws are going ahead or backing together. In other cases it may, *with out-turning screws,* be very important, and the more so because it *acts with and is added to the turning effect arising from the leverage of the screws.* Suppose the port screw going ahead. The leverage due to its position on the port side of the center-line throws the ship's head to starboard. At the same time the sidewise pressure of the lower blades, which, as has been explained, greatly outweighs that of the upper blades,

drags the stern to port, thus acting with the leverage of the screw to throw the head to starboard.

If, now, the starboard screw is backing, its leverage and the pressure of its lower blades also act to throw the stern to port, and the head to starboard. Moreover, the *discharge-current* from the upper blades of the backing screw is driven in against the starboard run and adds its effect to that of all the other forces which are acting to turn the ship to starboard.

It is evident then, that with out-turning screws all the factors which have any real moment, *act together* toward turning the ship, in the one important case in which the attempt is made to turn by going ahead with one screw and backing with the other.

With *in-turning* screws, we have still the important factor of leverage contributing to the turn, but this, instead of being reinforced by the other factors, is opposed by nearly all of them. The port screw, going ahead, tends as before to throw the ship's head to starboard, but the pressure of the blades is in the opposite direction.

Similarly, the leverage of the starboard screw, *backing*, tends to turn the head to starboard, but the pressure of the blades opposes it. And the discharge current against the stern, being now from the lower blades only, acts upon the sharper run near the keel and produces a comparatively trifling effect.

The net result of this conflict of forces in the case of in-turning screws *is practically to destroy the manœuvring power of the screws* and to make the behavior of the ship in any given case altogether uncertain.

We proceed to consider the turning of twin-screw ships with out-turning screws under various conditions:

We shall deal with the following cases:

1. Going Ahead.
2. Backing.
3. One screw going Ahead, the other Backing.
4. Ship going Ahead, both screws Backing.
5. Ship going Astern, both screws going Ahead.

1. Going Ahead.—So long as both screws are making the same speed, the ship should steer with helm amidships, unless affected by wind or sea.

If one screw is stopped, there should be no difficulty in steering a straight course with a moderate amount of helm.

If the steering gear is disabled, there should be no difficulty in making a reasonably good course, steering by the screws, unless the sea is heavy; but this supposes good and rapid communication between the bridge and the engines. In a seaway, there may be some difficulty about steering in this way, but not enough to prevent a ship from proceeding with perfect safety as long as she has sea-room; but we must, of course, recognize the fact that even under the most favorable conditions the screw can never give the sensitiveness of control that comes from a rudder governed by steam power. Experience shows that it is best to keep one engine turning over at a constant rate, somewhat less than the maximum available, and to steer the ship by varying the number of revolutions of the other screw.

If the helm be put hard over when going ahead at full speed, the result will be practically the same as in the case of a single screw. In fact, as already stated, the curves of Plate **93** have in some cases been derived from experiments upon twin-screw ships; and the discussions of these curves already given are entirely applicable to the case we are now considering. We have to recognize the same sweep of the stern to leeward, the same ranging ahead, along, and even to leeward of, the original course, before beginning to gain ground in the desired direction, and the same loss of speed while turning.

It is found that the revolutions of the inner screw are somewhat reduced in turning, the change amounting to perhaps 10 per cent.

From causes which cannot be clearly defined, and which are probably different with different ships, it usually happens that a twin-screw ship turns somewhat more readily to one side than to the other; but the difference is less than with single screws, and is of practical importance only in the case where a full turn is to be made—as in the tactical manœuvring of men-of-war.

2. Backing.—A twin-screw ship, starting from rest with both screws backing, should be entirely under the control of the rudder, though she will steer with much less ease and sensitiveness than when going ahead. If necessary, the rudder may be assisted by a variation in the speed of one or other of the two screws.

3. One Screw going Ahead, the other Backing.—(a) If the ship is just starting from rest, with helm amidships, she will turn rapidly to the side of the backing screw.

If the screws revolve at equal speed, the one going ahead will gain slightly upon the other, since less power is required to drive

a ship ahead than to drive her astern, and the ship will turn in a circle of small radius, but not on her heel.

If it is desired to turn her as nearly as possible on her heel, the screw going ahead should be kept at somewhat lower speed than the other, the exact relation between the two being determined experimentally for each ship.

The time of turning under these conditions is considerably greater than where both screws are kept going ahead and the helm put hard over, although the space required is much less.

Many ships will not turn *from rest* by going ahead on one screw and backing on the other. With such a ship, it is necessary to gather a little way and commence turning by the helm before backing the inner screw.

In the special case where the ship is to be turned without gathering headway, *the helm should be kept amidships.* To make this clear, let it be assumed that the turn is to be made to starboard. The starboard screw will be backing and the port screw going ahead. To starboard of the rudder, then, we shall have a suction current moving forward, and, to port, a discharge current moving aft. If, now, we put the helm hard aport[1] (rudder to starboard), the suction current will strike against the after side and tend to throw the head to port; while if we put the helm to starboard[2] (rudder to port), the discharge current will act against the forward side and will also tend to throw the head to port.

(b) If the ship is moving ahead at fair speed when one screw is backed for the purpose of turning, the helm should be put hard over as if the engines were both continued ahead. Wishing to turn to starboard, we put the helm hard aport, and reverse the starboard screw.

In this case, the suction current of the backing screw, acting upon the after side of the rudder, will oppose the turning, but not sufficiently to deprive the helm of all steering power, as it often does in the case of a single screw. There are several reasons for the difference. In the first place, only half the power of the ship is involved in the backing, whereas with a single screw, the whole power is involved. Again, the suction current in the present case is at some distance to one side, and affects only the outer part of the hard-over rudder; and, finally, the headway is prolonged by the other screw, and this tends to continue the normal action of the rudder.

In turning, then, with considerable headway, and wishing to

1. right rudder. 2. left rudder

get the maximum effect, the helm should be used as in ordinary turning, and the inner screw reversed.

As regards the track of the ship in turning under these conditions, we have seen that the curve of a twin-screw ship with both screws going ahead and helm hard over, does not differ materially from that of a single-screw ship; but it would be natural to suppose that the case must be greatly changed when the inner screw is reversed to help the helm. There is, in fact, a considerable difference, but it is far less than is commonly supposed; at least in the first brief interval after the turn begins; in the interval, that is to say, during which the emergency for which the action is taken must work itself out. The complete turning circles will be widely different, but the track of the vessel for some time will be but little modified. The stern will, as in all other cases, go off to leeward, and the ship will gain nothing to the side toward which her head is thrown, until she has covered from two to three lengths along her old track. She will, however, gradually lose her speed, and will throw her head around rather more sharply, with the result that, by the time she does begin to move away from her old line of advance, she will do so at a considerably greater angle than if her helm were merely put over without reversing the inner screw.

4. Ship going Ahead, both Screws Backing.—In this case, if the helm is kept amidships, the ship may be stopped in from three to five lengths.

If the helm is put hard over to either side, we have a case resembling that in which the screw of a single-screw steamer is suddenly reversed; but with some points of difference. In the present case, we shall have a suction current on each side drawn forward by the screw of that side. Whichever way the rudder is put, its direct steering action for headway will be opposed by the suction current of that side alone; that is to say, by only half the power of the total suction. Moreover, this current is so far to one side that its effect will be confined to a small part of the area of the rudder.

Thus the twin screws, in backing, will have much less tendency than a single screw, to reverse the ordinary steering effect of the rudder; and it is found that so long as the headway continues, the ship steers normally (for headway), but turns less rapidly under the influence of the helm than if the screws were going ahead; in other words, the screws in this case reduce, but do not reverse, the normal effect of the rudder.

There is an important gain in the rapidity of turning if the helm is put hard over before the screws are reversed, thus starting the head to swinging in the right direction.

5. SHIP GOING ASTERN, BOTH SCREWS GOING AHEAD.—In this case, the ship will obey her helm for sternboard, although the power of the rudder will be materially reduced by the discharge current of the screws.

If necessary, the rudder may be helped, and the ship manœuvred with ease and certainty, by varying the speed of the screws.

§ VIII.

ADDITIONAL NOTES UPON STEERING.

Effect of Wind.

If a steamer is lying in a smooth sea, with her engines stopped and with the wind abeam, she will gradually fall off and bring the wind abaft the beam; this for the reason that the draft is usually less forward than aft, so that the bow has less hold on the water than the stern; that, usually, the bow is higher than the stern and so presents a greater surface to the wind; and that, above all, the screw acts as a drag holding the stern up to the wind.

In going ahead, the wind has no important effect. In backing, there is a marked tendency for the stern to back up into the wind. This tendency increases with the force of the wind and the speed of the ship, and differs greatly with different ships. Some ships cannot be backed at all, even in a light breeze, without throwing their sterns up to it, even though all other forces are acting to turn them the other way.

It will be clear from the above that advantage may be taken of the wind in manœuvring, and that its effect will be felt much more decidedly in backing than in going ahead. We shall have the maximum of favorable conditions for turning, when the wind is fresh on the port hand. Under these conditions, everything favors turning to starboard; and it will be difficult, if not impossible, to turn to port.

The problem of handling a ship becomes one of especial difficulty when she is flying light. In this condition, she has less hold on the water and exposes more surface to the wind. Moreover, the effective rudder area is reduced, and the steering effect

of the screw, due to incomplete immersion, is very greatly increased. Thus everything acts to minimize the control of the ship by the rudder. Under these conditions, a steamer may steer fairly well so long as she is in the open sea and under full speed, but she will handle very badly in a harbor, where she has no opportunity to get up speed; and if the breeze is fresh she will be nearly or quite unmanageable. The effect of the screw is to throw her stern off to the side from which the lower blades are moving; so that the bow falls off to port in going ahead, and to starboard in backing. If the wind and screw act together in any given case, the rudder will be practically useless if acting against them; if they oppose each other, it may have some power to control the ship, but the power will, at best, be far below what it is in ordinary conditions of trim.

It can hardly be necessary to state that the ship when flying light will drift bodily to leeward much more rapidly than under ordinary conditions; and that the tide is of relatively greater importance than usual, because of the comparative helplessness of the ship.

Effect of Sea.

A ship lying at rest in a seaway will gradually fall off into the trough of it, and some effort will be required to hold her up. If going ahead, she will tend to keep in the trough, and lee helm will be needed to bring her head to it; but if the engines are backed, she will throw her stern up to the sea exactly as she would to the wind, and this in spite of all that can be done to prevent it.

The longer the ship, the more decided will be the tendency to lie in the trough of the sea.

There may be special features of design or of the trim which will materially affect the steering of the ship. If she trims by the head, she may, when lying at rest with a beam wind, gradually throw her head up to it instead of her stern, although the chances are that the drag of the screw will prevent this.

If her after deadwood is cut away somewhat more than in ordinary designs, her hold upon the water will be reduced and there may be difficulty in holding her to a straight course. On the other hand, she will be very sensitive to small changes of helm, and will turn in small space, her stern being thrown off to leeward very decidedly by hard-over helm. Most of these points

are well shown in connection with the Yashima, but it is stated that this ship steers very steadily, the reason for this being that her rudder, which is of unusually large area, is hung *beneath* the stern in such a way that, when, amidships, it takes the place of the deadwood which is cut away.

EFFECT OF SHALLOW WATER.—It is well known that ships do not manœuvre as well in shallow as in deep water, and it not infrequently happens that a vessel which steers perfectly in the open sea becomes very wild in channels where she has only a few feet of water under her keel. The explanation lies in the fact that the displaced water cannot flow off freely along the natural wave lines due to the shape of the under-water body. For similar reasons, the speed is reduced in shallow water as compared with that due to the same power in water deep enough to allow a free flow of the displaced water.

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The preceding sections, as carefully explained in the beginning, relate to ships of average characteristics in all respects. They illustrate principles which are broadly true of all ships, but which must be modified in one direction or another if we seek to apply them to ships of exceptional build, speed, trim or manœuvring power. This is illustrated in the turning curve of the Yashima, already referred to. The facts that her after deadwood is cut away much more than is usual, that her rudder is exceptionally large, and that her steering-gear admits of putting the helm over very quickly, result in an excessive "kick;" and this, coupled with the momentum due to high speed, results in the peculiarities which have been noted in her turning circle. If, in addition to the features just detailed, she were of light draft and flat bottom, certain of her peculiarities would be exaggerated still further, the conditions in such a case approximating to those involved in the turning of torpedo-boats, in which we have very high speed and extraordinary turning power associated with light draft and a floor comparatively flat. Such a boat, upon putting her helm hard over at full speed, turns sharply, but may drive along her original line even after she has turned her broadside nearly full towards it. In the manœuvring of such a craft as this, there is brought out strikingly another point which to a greater or less degree appears in all cases of turning. This is the outward heel of the ship, due to the momentum and the centrifugal force acting outward from the center, and to the

lateral resistance of the water, which acts inward, but usually below the center of gravity, so that it adds to outward heel. These heeling forces are to some extent offset by the lateral water pressure on the rudder, which, acting on the inside, and below the center of gravity, has a tendency to produce inward heel. The heeling of large ships in turning is rarely of practical importance; but in torpedo-boats it may be a source of considerable danger. Suppose such a boat, whose build happens to be favorable for heeling, to be turning at full speed and with hard-over helm while at the same time rolling more or less in a seaway. The hard-over helm acts, as already noted, to counteract the other forces and reduce the outward heel. If, now, the helm is suddenly eased, this counteracting force is removed, and the boat lurches sharply outward; and if it happens that she is at the same instant rolled outward by an impulse from a wave, she may be unable to recover and may capsize.

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The forces thus far described as involved in the turning of a ship are all more or less under the control of those who must manœuvre her; or, if not under control, must be understood in order that she may be handled intelligently. They are thus properly matters of *Seamanship*. It will be interesting now to glance at a few points of a slightly different kind.

As the helm is put over, the ship begins to turn, or to acquire angular velocity, and for our present purpose we may consider the turning as taking place about the center of gravity of the ship. The turning is opposed by the resistance of the water to lateral displacement of the bow and stern; but as, in the beginning, this resistance is small—the turning being slow—the velocity of turning rapidly increases. This increase results in a still more rapid increase of resistance, and presently the two sets of forces, those producing and those opposing, the angular velocity, balance each other, and this velocity becomes constant. From this time on, the ship turns in a curve which is practically a circle, her bow maintaining a steady angle, technically known as the "drift angle," to the tangent of the circle.

An important point in connection with the turning of a ship has to do with what is known in mechanics as the "moment of inertia," of which we need only explain here that it depends upon the distribution of weights in the ship with reference to the center of gravity. The significance of this point may be made clear by

a simple illustration. Suppose we have a long rod pivoted at its middle point (the center of gravity) and carrying on each side of the pivot a weight which may be moved in and out. If the weights are kept close in to the pivot, the rod will be easily turned and stopped; whereas if the weights are run out to the ends, a much greater effort will be required to start it, and, after it is started, to stop it. In the first case, the moment of inertia is small and the rod is easily controlled; in the second, the moment of inertia is large, and considerable force is required to control it. Similarly, ships with their weights near the ends have large moments of inertia and are more difficult to manœuvre than those whose weights are concentrated more nearly amidships, and whose moments of inertia are accordingly small.

It is important that all officers should be familiar with the manœuvring peculiarities of the ships which they are called upon to handle, and every effort should be made to determine and record these peculiarities at the very beginning of her service, a "ship's book" being kept, in which the results of all experiments are carefully entered. This book should contain the following information:

1. The turning circles of the ship, with starboard and port helm,[1] and with different degrees of helm, carefully plotted to scale and showing the "kick," the "drift angle," the "tactical diameter," the "advance," the "transfer," etc.

2. The time and distance required to bring the ship to rest by backing with full power at several different speeds.

3. The behavior of the ship in stopping under the conditions of 2; whether the head goes to starboard or to port and how far.

4. The result of putting the helm over either way during the manœuvre of 2.

5. The effect upon this manœuvre of using a reserve of power for backing.

6. The effect upon this manœuvre of varying the time at which the helm is put over; before reversing the engines, after reversing, simultaneously with reversing.

7. The effect of wind in backing.

8. The best way to work helm and engines for turning in a limited space, and the shortest space in which the ship can be turned.

1. left and right rudder.

CHAPTER XII.

RULES OF THE ROAD.

REGULATIONS FOR PREVENTING COLLISION.

§ I.

The Regulations for Preventing Collision include the following:

1. **The International Rules**, established by agreement between maritime nations as governing navigation on the high seas and in all waters connected therewith navigable by sea-going vessels. See § II of this Chapter.

Article 30 of the International Rules, reads as follows:

" Nothing in these Rules shall interfere with the operation of a special rule duly made by local authority, relative to the navigation of any harbor, river, or inland waters."

2. **The Inland Rules** enacted by Congress and governing the navigation of the inland waters of the United States. § III.

Where important differences exist between the International Rules and the United States Inland Rules, the differences are marked in the latter (§ III) by special type.

3. **The Pilot Rules** for United States Inland Waters, supplementing the Inland Rules.

These Rules are established by the Board of Supervising Inspectors of Steam Vessels, and are published in a pamphlet entitled " Pilot Rules for Atlantic and Pacific Coast Inland Waters." § V. This pamphlet can be obtained from the Inspector of Steam Vessels at the Custom House of any port of entry, and should be in the hands of all officers of vessels navigating the inland waters of the United States.

4. **Local Regulations** for the navigation of various harbors, rivers, etc., of countries other than the United States.

These rules are numerous and in some cases important, but they must in general be obtained from pilots or other local authorities. Many of them, however, are published in convenient form in " The Rules of the Road at Sea," by H. Stuart Moore.

Interesting and important decisions by the courts in connection with the Rules of the Road can be found, usually under the heading "Collision," in numerous publications which report such decisions. These publications are accessible in convenient form in most large libraries. Especially convenient are the files of the "Federal Reporter," and the "Federal Reporter Digest." The last-named gives, in a few volumes, a brief digest of all important decisions under "Collision" with sub-heads, such as "Speed in a Fog," "Lights," etc.

Other valuable works on the subject are:

Collisions at Sea, by R. G. Marsden, published by Stevens & Sons, London.

Collision at Sea, by Julian B. Swope, published by The American Law-Book Co.

Rules of the Road at Sea, by H. Stuart Moore, published by J. D. Potter, London.

A Treatise on the Law of Marine Collisions, by Herbert R. Spencer, published by Callaghan & Co., Chicago.

§ II.

INTERNATIONAL RULES.

Preliminary Definitions.

In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "**steam-vessel**" shall include any vessel propelled by machinery.

A vessel is "**under way**" within the meaning of these rules when she is not at anchor, or made fast to the shore, or aground.

II.—LIGHTS, AND SO FORTH.

The word "**visible**" in these rules when applied to lights shall mean visible on a dark night with a clear atmosphere.

Article 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-vessels—Masthead Light.

Art. 2. A steam-vessel when under way shall carry—(a) On or in front of the foremast, or if a vessel without a foremast, then in the forepart of the vessel, at a height above the hull of not less than twenty feet, and if the breadth of the vessel exceeds twenty feet, then at a height above the hull not less than such breadth, so, however, that the light need not be carried at a greater height above the hull than forty feet, *a bright white light,* so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least *five miles.*

Steam-vessels—Side-lights.

(b) On the starboard side a *green light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) On the port side a *red light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

(d) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.[1]

NOTE 1.—A very little consideration will show that these lights can not be prevented from showing to some extent across the bow. The flame of the lamp must have a certain width, and the lamp as a whole must stand out at some distance from the inboard screen. In addition to this, there will always be a reflection, visible at a certain distance, from the outer (after) side of the light box. The mere use of a screen projecting three feet forward can do very little toward correcting this. The matter is a serious one, involving danger which is the greater because seldom realized. If we see all the lights of a steamer, we assume, and the law justifies us in assuming (see Art. 18), that she is heading directly toward us. But if her lights show a point across the bow, we may misjudge her course

by a point; and if she makes a corresponding error with regard to our lights and our course, the situation may be one of grave danger.

Although this difficulty can not be entirely done away with, it can be much reduced, by a batten of wood placed vertically along the forward edge of the fore and aft screen, and projecting out-board so that its outer edge shall be tangent to a line drawn through the inner edge of the wick, parallel to the keel line.

A light so screened will still show nearly or quite half a point across the bow, depending upon the width of the wick. This width is fixed by an English rule at "not less than one inch, nor more than two inches." A two-inch wick screened as above will show nearly 4° across the bow.

In inspecting the lights and their fittings, it is important to see that the after screen complies with the requirement that the light shall show only 2 points abaft the beam.

Steam-vessels—Range-lights.

(e) A steam-vessel when under way *may* carry *an additional white light* similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.[2]

NOTE 2.—The range-lights, as herein described, while giving far less information than they might be made to give if their position were more definitely fixed by law, are nevertheless so useful that it is to be hoped they may, before many years, be made compulsory for all steamers at all times when under way. They are at present compulsory within the interior waters of the United States for all other than "sea-going" steamers and ferry-boats. (See "Inland Rules" for United States. Art. 2. f.)

It is clear that, supposing a vessel carrying such lights to be seen on an even keel, the lights will show one above the other when she is heading toward the observer; that if she changes course, the lights will open out, the lower one (which is also the forward one), drawing away from the upper one, in the direction to which the ship's head is changing. If the position of the lights were definitely fixed by law, the angle of the line joining them would be an indication of the course steered; but since neither the vertical nor the horizontal distance between them is established, they can not usually be regarded as giving much more information about the course than is given by side-lights. They have, however, one very great advantage over side-lights, in that, after being once clearly sighted, a change in their relative position gives instant notice of a change of course. This indication is especially sensitive when the vessel carrying the light is heading

toward the observer, or nearly toward him, and this happens to be the point where the signals given by side-lights are often dangerously misleading. (See note 1.)

There is, of course, the farther very great advantage in range-lights over side-lights, that they can be seen at a much greater distance and thus give earlier notice as to the approximate course of the steamer carrying them. Their value would be considerably increased if we could be sure of finding associated with them the permanent white stern light *permitted* by the second part of Art. 10; but as the law stands, these two "permissive" clauses have no connection with each other, and we are not justified in assuming that a steamer which carries range-lights will also carry a permanent stern light.

It should be noted that when the vessel carrying range-lights is seen end-on, these lights may be confused with the lights of a vessel towing.

If the vessel carrying the range-lights has a list, this will be indicated, to an observer seeing her end-on, by the inclination of the side-lights.

Steam-vessels—When Towing.

Art. 3. A steam-vessel when **towing** another vessel shall, in addition to her side-lights, carry *two bright white lights* in a vertical line one over the other, not less than six feet apart,[3] and when towing **more than one vessel** shall carry *an additional bright white light* six feet above or below such light, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two[4] (a), excepting the additional light, which may be carried at a height of not less than fourteen feet above the hull.[5]

Such steam-vessels may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

NOTE 3.—These lights may be confused with the range-lights of a steamer seen end-on. Moreover, the range-lights and towing-lights may be carried by the same vessel, which may thus, when seen end-on, show as many as four lights in a vertical line.

NOTE 4.—Under Art. 9 (b), fishing-vessels off the European coast north of Cape Finisterre, carry, when fishing with drift-nets, two white lights, which may be confused with those of vessels towing. This calls for caution. A steamer in the neighborhood of a fishing ground, and having, perhaps, passed a number of fishing boats showing these lights, might easily fail to recognize a steamer towing, if she should chance to meet one.

NOTE 5.—That is to say, if two lights are carried, the lower one shall comply, as to height, with the requirements of Art. 2, for the regular masthead light; and if three are carried, the middle one shall comply with these requirements.

It is found that two lights separated by six feet blend into a single light at distances beyond about four miles.

Special Lights.

Art. 4. (a) A vessel which from any accident is **not under command** shall carry at the same height as the white light mentioned in article two (a), where they can best be seen, and if a steam-vessel in lieu of that light, *two red lights,* in a vertical line one over the other, not less than six feet apart, and of such a character as to be visible all around the horizon at a distance of at least two miles; and shall by day carry in a vertical line one over the other, not less than six feet apart, where they can best be seen, *two black balls or shapes,* each two feet in diameter.

(b) A vessel employed in laying or in picking up a **telegraph cable** shall carry in the same position as the white light mentioned in article two (a), and if a steam-vessel, in lieu of that light, *three lights* in a vertical line, one over the other, not less than six feet apart. The highest and lowest of these lights shall be *red,* and the middle light shall be *white,* and they shall be of such a character as to be visible all around the horizon at a distance of at least two miles.* By day she shall carry in a vertical line, one over the other, not less than six feet apart, where they can best be seen, *three shapes* not less than two feet in diameter, of which the highest and lowest shall be globular in shape and *red* in color, and the middle one diamond in shape and *white.*

NOTE 6.—The middle one of these lights, being white, will usually be seen before the others, and may be mistaken, until the other lights are seen, for a steamer's masthead light.

(c) The vessels referred to in this article, when not making way through the water, shall not carry the side-lights, but when making way shall carry them.

(d) The lights and shapes required to be shown by this article are to be taken by other vessels as signals that the vessel showing them is **not under command** and can not therefore get out of the way.

These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in article thirty-one.

Lights for Sailing-vessels and Vessels in Tow.

Art. 5. A sailing-vessel under way and any vessel being towed shall carry the same lights as are prescribed by article two for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

Lights for Small Vessels.

Art. 6. Whenever, as in the case of small vessels under way during bad weather, the green and red side-lights can not be fixed, these lights shall be kept at hand, lighted and ready for use; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side, nor, if practicable, more than two points abaft the beam on their respective sides. To make the use of these portable lights more certain and easy the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with proper screens.

Lights for Small Steam- and Sail-Vessels and Open Boats.

Art. 7. Steam-vessels of less than forty, and vessels under oars or sails of less than twenty tons gross tonnage, respectively, and rowing boats, when under way, shall not be required to carry the lights mentioned in article two (a), (b), and (c), but if they do not carry them they shall be provided with the following lights:

First. **Steam-vessels of less than forty tons** shall carry—

(a) In the forepart of the vessel, or on or in front of the funnel, where it can best be seen, and at a height above the gunwale of not less than nine feet, a bright white light constructed and fixed as prescribed in article two (a), and of such a character as to be visible at a distance of at least two miles.

(b) Green and red side-lights constructed and fixed as prescribed in article two (b) and (c), and of such a character as to be visible at a distance of at least one mile, or a combined lantern showing a green light and a red light from right ahead to two points abaft the beam on their respective sides. Such lanterns shall be carried not less than three feet below the white light.

Second. **Small steamboats**, such as are carried by sea-going vessels, may carry the white light at a less height than nine feet

above the gunwale, but it shall be carried above the combined lantern mentioned in subdivision one (b).

Third. **Vessels under oars or sails of less than twenty tons** shall have ready at hand a lantern with a green glass on one side and a red glass on the other, which, on the approach of or to other vessels, shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fourth. **Rowing boats**, whether under oars or sail, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to prevent collision.

The vessels referred to in this article shall not be obliged to carry the lights prescribed by article four (a) and article eleven, last paragraph.

Lights for Pilot-vessels.

Art. 8. **Pilot-vessels** when engaged on their stations on pilotage duty shall not show the lights required for other vessels, but shall carry a *white light* at the masthead, visible all around the horizon,[7] and shall also exhibit a *flare-up light* or flare-up lights at short intervals, which shall never exceed fifteen minutes.

NOTE 7.—This may be mistaken for a steamer's masthead light.

On the near approach of or to other vessels they shall have their side-lights lighted, ready for use, and shall flash or show them at short intervals, to indicate the direction in which they are heading, but the green light shall not be shown on the port side, nor the red light on the starboard side.

A pilot-vessel of such a class as to be obliged to go alongside of a vessel to put a pilot on board may show the white light instead of carrying it at the masthead, and may, instead of the colored lights above-mentioned, have at hand, ready for use, a lantern with green glass on the one side and a red glass on the other, to be used as prescribed above.

Pilot-vessels, when not engaged on their station on pilotage duty, shall carry lights similar to those of other vessels of their tonnage.

> **A steam pilot-vessel,**[8] when engaged on her station on pilotage duty and *in waters of the United States,* and not at anchor, shall, in addition to the lights required for all pilot boats, carry at a distance of eight feet below her white mast-

head light *a red light,* visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored *side-lights* required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and at anchor, she shall carry in addition to the lights required for all pilot boats the red light above-mentioned, but not the colored side-lights. When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

NOTE 8.—This Rule was adopted by the United States in 1900. A similar Rule has been adopted by Great Britain, but not by other Maritime Powers. Thus the rule is not, in fact, International.

Lights, etc., of Fishing Vessels.[9]

NOTE 9.—This International Article went into effect January 1, 1908.

Art. 9. Fishing-vessels and fishing boats, when under way, and when not required by this article to carry or show the lights hereinafter specified, shall carry or show the lights prescribed for vessels of their tonnage under way.

(a) **Open boats,** by which is to be understood boats not protected from the entry of sea water by means of a continuous deck, when engaged in **any** fishing at night, with outlying tackle extending not more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry *one all-round white light.*

Open boats, when fishing at night, with outlying tackle extending more than one hundred and fifty feet horizontally from the boat into the seaway, shall carry *one all-round white light,* and in addition, on approaching or being approached by other vessels, shall show *a second white light* at least three feet below the first light and at a horizontal distance of at least five feet away from it **in the direction in which the outlying tackle is attached.**

(b) Vessels and boats, except open boats as defined in subdivision (a), when fishing with **drift-nets,**[10] shall, so long as the nets are wholly or partly in the water, carry *two white lights* where they can best be seen. Such lights shall be placed so that the vertical distance between them shall be not less than six feet and not more than fifteen feet, and so that the horizontal distance between them, measured in a line with the keel, shall be not less

than five feet and not more than ten feet. The lower of these two lights shall be in the direction of the nets, and both of them shall be of such a character as to show all around the horizon, and to be visible at a distance of not less than three miles.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing-vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the net or gear) a white light, visible at a distance of not less than one sea mile, on the approach of or to other vessels.

(c) Vessels and boats, except open boats as defined in subdivision (a), when **line fishing** with their lines out and attached to or hauling their lines, and when not at anchor or stationary within the meaning of subdivision (h), shall carry *the same lights as vessels fishing with drift-nets*. When shooting lines, or fishing with towing lines, they shall carry the lights prescribed for a steam- or sailing-vessel under way, respectively.

Within the Mediterranean Sea and in the seas bordering the coasts of Japan and Korea sailing fishing-vessels of less than twenty tons gross tonnage shall not be obliged to carry the lower of these two lights. Should they, however, not carry it, they shall show in the same position (in the direction of the lines) a white light, visible at a distance of not less than one sea mile on the approach of or to other vessels.

NOTE 10.—A distinction is drawn in Art. 9 between two important methods of fishing.—*Trawlers, dredgers,* and *drag-net* fishers, run usually with the tide, dragging a net or scoop along the bottom. Their speed, under favorable circumstances, rarely exceeds two or three knots, and their power of manœuvring is of course very limited. These vessels are usually of considerable size (from 50 to 100 tons), and their work is carried on in deep water and often at great distances from shore. If the trawl or dredge catches on the bottom, the vessel is virtually at anchor, and shows the regular anchor lights.

Fishing by *drift-nets* and *lines* is carried on by vessels drifting, and, of course, unable to manœuvre for the avoidance of collision.

Drift-nets are laid out with the wind and the vessel rides head to wind to leeward of her nets, which may be as much as two miles in length, stretching off to windward, and buoyed at certain distances. *Lines* are laid out across the tide, and may be six or eight miles in length, marked at intervals by small buoys carrying flags. These buoys are not to float the line, but only to mark it. At the end of the

line is a light anchor or other weight, which drags along the bottom, keeping the lines well down but not holding the boat.

Drift-net fishing is principally done by night, line fishing by day, trawling by both night and day.

The methods of fishing to which this article applies are carried on by many thousands of vessels along the coasts of Europe north of Cape Finisterre, in certain parts of the Mediterranean, and in the waters of China and Japan.

(d) Vessels when engaged in trawling, by which is meant the dragging of an apparatus along the bottom of the sea—

First. *If steam-vessels* shall carry in the same position as the white light mentioned in article two (a) *a tri-colored lantern* so constructed and fixed as to show a *white light* from right ahead to two points on each bow, and *a green light and a red light* over an arc of the horizon from *two points on each bow to two points abaft the beam* on the starboard and port sides, respectively; and not less than six nor more than twelve feet below the tri-colored lantern a *white light* in a lantern, so constructed as to show a clear, uniform, and unbroken light *all around the horizon.*

Second. *If sailing-vessels,* shall carry a white light in a lantern, so constructed as to show a clear, uniform, and unbroken light all around the horizon, and shall also, on the approach of or to other vessels, show where it can best be seen a white *flare-up light* or torch in sufficient time to prevent collision.

All lights mentioned in subdivision (d) first and second shall be visible at a distance of at least two miles.

(e) Oyster dredgers and other vessels fishing with dredge-nets shall carry and show the same lights as trawlers.

(f) Fishing-vessels and fishing boats may at any time use a flare-up light in addition to the lights which they are by this article required to carry and show, and they may also use working lights.

(g) Every fishing-vessel and every fishing boat under one hundred and fifty feet in length, *when at anchor,* shall exhibit a white light visible all around the horizon at a distance of at least one mile.

Every fishing-vessel of one hundred and fifty feet in length or upward, *when at anchor,* shall exhibit a white light visible all around the horizon at a distance of at least one mile, and shall

exhibit a second light as provided for vessels of such length by article eleven.

Should any such vessel, whether under one hundred and fifty feet in length or of one hundred and fifty feet in length or upward, be attached to a net or other fishing gear, she shall on the approach of other vessels show *an additional white light* at least three feet below the anchor light, and at a horizontal distance of at least five feet away from it **in the direction of the net or gear.**

(h) If a vessel or boat when fishing becomes stationary in consequence of her gear getting fast to a rock or other obstruction, she shall in daytime haul down the day signal required by subdivision (k); at night show the light or lights prescribed for a vessel at anchor; and during fog, mist, falling snow, or heavy rainstorms make the signal prescribed for a vessel at anchor. (See subdivision (d) and the last paragraph of article fifteen.)

Fog-Signals for Vessels Fishing.

(i) In fog, mist, falling snow, or heavy rainstorms drift-net vessels attached to their nets, and vessels when trawling, dredging, or fishing with any kind of drag net, and vessels line fishing with their lines out, shall, if of twenty tons gross tonnage or upward, respectively, at intervals of not more than one minute make a *blast;* if steam-vessels, with the whistle or siren, and if sailing-vessels, with the fog-horn, *each blast to be followed by ringing the bell.* Fishing-vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals; but if they do not, they shall make some other efficient sound signal at intervals of not more than one minute.

(k) All vessels or boats fishing with nets or lines or trawls, when under way, shall in daytime indicate their occupation to an approaching vessel by displaying a *basket* or other efficient signal where it can best be seen. If vessels or boats at anchor have their gear out, they shall, on the approach of other vessels, show the same signal *on the side on which those vessels can pass.*

The vessels required by this article to carry or show the lights hereinbefore specified shall not be obliged to carry the lights prescribed by article four (a) and the last paragraph of article eleven.

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being **overtaken** by another shall show from her stern to such last-mentioned vessel a *white light* or a flare-up light.

The white light required to be shown by this article may be fixed and carried in a lantern, but in such case the lantern shall be so constructed, fitted, and screened that it shall throw an unbroken light over an arc of the horizon of twelve points of the compass, namely, for six points from right aft on each side of the vessel, so as to be visible at a distance of at least one mile. Such light shall be carried as nearly as practicable on the same level as the side-lights.

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length, when at anchor,[11] shall carry forward, where it can be best seen, but at a height not exceeding twenty feet above the hull, a *white light* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile

A vessel of one hundred and fifty feet or upwards in length, when at anchor, shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, *one such light,* and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, *another such light.*

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

A vessel **aground** in or near a fair-way shall carry the above light or lights and the two red lights prescribed by article four (a).

NOTE 11.—A vessel is at anchor under the law when she is fixed by some means to the soil, when she is made fast to a buoy which is itself fixed to the soil, and when she is moored to a dock. (See the definition of "under way" in the preliminary clause of these rules.)

Special Signals.

Art. 12. Every vessel may, if necessary in order to attract attention, in addition to the lights which she is by these rules

required to carry, show a *flare-up light* or use any detonating signal that can not be mistaken for a distress signal.[12]

NOTE 12.—This may be very useful to attract the attention of a ship whose duty it is to keep clear, if she does not show a disposition to act. A detonating signal would be especially valuable, and such signals should be kept on the bridge. (See note 24.)

Naval Lights and Recognition Signals.

Art. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal-lights for two or more ships of war or for vessels sailing under convoy, or with the exhibition of recognition signals adopted by ship owners, which have been authorized by their respective Governments and duly registered and published.

Steam-vessel under Sail by Day.

Art. 14. A steam-vessel proceeding under sail only **but having her funnel up**, shall carry in day-time, forward, where it can best be seen, *one black ball or shape* two feet in diameter.

III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

Preliminary.

Art. 15. All signals prescribed by this article for vessels under way shall be given:

First. By "steam-vessels" on the whistle or siren.

Second. By "sailing-vessels" and "vessels towed" on the fog horn.

The words *"prolonged blast"* used in this article shall mean a blast of from four to six seconds' duration.

A steam-vessel shall be provided with an efficient whistle[13] or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog-horn, to be sounded by mechanical means, and also with an efficient bell. (In all cases where the rules require a bell to be used a drum may be substituted on board Turkish vessels, or a gong where such articles are used on board small sea-going vessels.) A sailing-vessel of twenty tons gross tonnage or upward shall be provided with a similar fog-horn and bell.

NOTE 13.—It is not easy to say what an "efficient" signal should be capable of doing; but we may probably insist that, under reasonably favorable conditions of wind and weather, a whistle should be heard not less than two miles, a fog-horn and bell not less than one mile. It would, however, be dangerous to rely upon hearing signals at these or any other definite distances, so many and so seemingly erratic are the atmospheric conditions which modify the audibility of sound. A sound which, under most circumstances, would be clearly heard several miles, may, by some peculiar conditions of the atmosphere, be inaudible at a quarter of a mile. It is fairly well established, that sounds are heard rather better in a fog or snow than in clear weather (other things being equal); that sound travels better with the wind than against it; that a strong breeze breaks up all sounds, and that when the upper and lower strata of air are moving in contrary directions, sounds are particularly unreliable.

In fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

Steam-vessel under Way.

(a) A steam-vessel **having way upon her** shall sound, at intervals of not more than two minutes, a *prolonged blast.*[14]

NOTE 14.—It is clear that the blast from a whistle might be so prolonged or so frequent as to lessen unduly the probability of hearing a signal from another vessel. There is also, no doubt, some danger that the hearing of an officer on the bridge may be in a measure dulled by the too frequent sound of his own whistle.

It will be agreed by most seamen, however, that two minutes is much too long a time between signals; and the general practice of men-of-war and well regulated merchant steamers seems to be to make this interval, as nearly as may be, one minute, and to give the blast a length of from four to six seconds.

There are electrical devices on the market, by which the whistle is sounded automatically, at regular intervals and for a fixed length of time, thus relieving the officer of the watch and the quartermaster of all thought in the matter, and leaving them free to give their undivided attention to duties from which, in a fog, they never should be diverted.

The interval between signals is closely connected with the question of speed in a fog.

(b) A steam-vessel under way, **but stopped,** and having no way upon her, shall sound, at intervals of not more than two minutes, ***two prolonged blasts,*** **with an interval of about one second between.**[15]

NOTE 15.—The power to distinguish, in a fog, between a vessel moving and one stationary, is very important. Properly used, this signal should be interpreted by another vessel hearing it, to mean, "The way is off my ship; you may feel your way past me."

A caution is required in connection with the interval (two minutes) permitted between signals. The law probably intended to require that a steamer, having thus indicated that she is stationary, should remain so until she gives another signal and a different one—in other words, if a vessel which has been stationary, starts her engines, she should, by the time she gathers way, give the signal for a vessel moving, *without reference to the interval which has elapsed since her last signal.* Otherwise, she might gather way and actually move a considerable distance before indicating to vessels in her vicinity that she was no longer at rest and in the position where they would have every reason for placing her.

It is important to note that from the time two vessels sight each other, the sound signals of this article give way to the sound signals of Art. 28 for "Vessels in sight of each other."

Sail-vessel under Way.

(c) A *sailing-vessel* under way shall sound, at intervals of not more than one minute:

When on the **starboard tack,** *one blast.*

When on the **port tack,** *two blasts* in succession.

When with the wind **abaft the beam,** *three blasts* in succession.

(d) A vessel when at **anchor** shall, at intervals of not more than one minute, *ring the bell rapidly for about five seconds.*

Vessels Towing or Towed and Vessels Unable to Manœuvre.

(e) A vessel when **towing,**[16] a vessel employed in laying or in picking up a **telegraph cable,** and a vessel under way, which is unable to get out of the way of an approaching vessel through being **not under command,** or unable to manœuvre as required by the rules, shall, instead of the signals prescribed in subdivisions (a) and (c) of this article, at intervals of not more than two minutes, sound three blasts in succession, namely: *One prolonged blast followed by two short blasts.* A vessel towed may give this signal and she shall not give any other.

NOTE 16.—Observe that a vessel towing is here classed with vessels unable to manœuvre in accordance with these rules when "in a fog, mist, falling snow, or heavy rainstorm." We shall see, however (Art. 16), that she is not relieved from the obligations laid upon

other vessels, of running at a moderate speed, stopping in case of danger, and proceeding with caution; nor from the obligations as to manœuvring which are prescribed for steam-vessels meeting and crossing. It is evident, however, that a vessel with another vessel in tow is not by any means as free to manœuvre as if she were unincumbered. She can not stop and back as readily as other vessels, and even if she does this herself, she is powerless to stop or back the tow. It has been repeatedly held by the courts that other vessels are bound to take these limitations into account and to make due allowance for them, not only in a fog, but at all other times. In other words a towing-vessel must, *as far as possible*, comply with the Rules; but other vessels must not expect her to do things *which are manifestly impossible*.

The fog-signal prescribed for a vessel towing, and the lights which such a vessel shows at night, are therefore to be regarded as throwing upon other vessels an obligation to manœuvre with especial caution. And this obligation is of course greater in a fog than at any other time.

Small Sailing-vessels and Boats.[17]

Sailing-vessels and boats of less than twenty tons gross tonnage shall not be obliged to give the above-mentioned signals, but if they do not they shall make some other efficient sound-signal at intervals of not more than one minute.

NOTE 17.—See Art. 9 for the fog-signal to be used by fishing-vessels.

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a **moderate speed**, having careful regard to the existing circumstances and conditions.[18]

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.[19, 20]

NOTE 18.—There is no point in connection with seamanship or admiralty law about which there has been as much discussion as about this question of "moderate speed" in a fog. The debates on it fill a hundred pages or more in the report of the International Marine Conference by which the present rules were drawn up. It was contended that a law upon which so much depended ought not to be left open to any doubt; and that the maximum speed at which a vessel might run in a fog should be definitely fixed by a law which no one could violate except willfully and at his peril.

This subject will be treated as a matter of seamanship in a later chapter. As a matter of law, it may be said that the courts of both England and America have held that "moderate" speed is such speed as will enable a vessel to bring herself to rest before coming into collision with any other vessel which she can sight through the fog in its existing condition, assuming that the other vessel is also running at a proper speed under this Rule, and that both vessels act promptly to prevent collision. In a dense fog, this calls for the very lowest speed which is consistent with steerage way; and steamers have been found at fault when running less than five knots. If the fog is so dense that a ship which has barely steerage way and a good reserve of power can not see another in time to avoid her even at that low speed, then the law requires vessels to stop, and, if circumstances permit it, to anchor. This is unquestionably the *law* in the matter, and we are not at present considering its wisdom, or the general practice of seamen in connection with it.

On the other hand, it has been held by the courts of both England and the United States that a higher speed is permissible in the open sea, where the probability of falling in with other ships is very slight, than in crowded waters or on fishing grounds. When in the neighborhood of shoals and particularly in channels where currents are strong and unknown, it may be dangerous to slow beyond a certain point, and a court would doubtless accept such a plea as a valid reason for maintaining a speed which under other circumstances would be excessive. This is fully covered by the phrase "having careful regard to the existing circumstances and conditions." But the burden of proof is thrown upon the ship maintaining such speed. There can be no question that the custom commonly followed by the great ocean liners, of running through dense fogs at a speed only a few knots below their maximum, is, in the eyes of the law, altogether unjustifiable.

This subject is one of such importance, and the views held by seafaring men with regard to it are so vague, that it is considered worth while to append a number of decisions of the courts dealing with the subject. These decisions will be found recorded, in conveniently accessible form, in the files of the "**Federal Reporter**," which can be seen in almost any large library.

Extract from the decision in the case of the BOLIVIA (speed 7 to 8 knots, off Fire Island):

"The steam-ship must also be held in fault because she was not going at a moderate speed in the fog, under the special circumstances and conditions of the case. She has given no evidence to show what speed she was required to maintain in order to keep steerage-way, and none to show that at a lower rate of speed than 7 or 8 knots she would not have been under efficient control, and able to govern her own movements promptly and effectually. Under the existing state of fog, and exercising the best vigilance, she could not discover another vessel

more than 300 or 400 feet away, yet maintained such a speed that, after reversing, her headway through the water could not be stopped within three times that distance.

"The locality was one frequented by numerous vessels in the coasting trade, and lay in one of the paths of the ocean traffic between Europe and the principal commercial port of this country. The steam-ship had but just passed a sister steam-ship of her own line, bound in an opposite direction; and the schooner had seen or heard several vessels during the previous half hour of the fog. Under such circumstances, it is not enough that the steam-ship moderated her speed; she should have reduced it to that moderate speed which was safe and prudent, in view of all the circumstances and conditions of the case. The rule is firmly established in this country, and also in England, that the speed of a steam-ship is not moderate, at least in localities where there is a likelihood of meeting other vessels, if it is such that she cannot reverse her engines and be brought to a stand-still within the distance at which, in the condition of the fog, she can discover another vessel."—Federal Reporter, No. 49, page 171.

From the decision in the case of the COLUMBIAN (speed 9 to 10 knots on La Have Bank):

"The only fault alleged against the steamer is excessive speed and the authorities make it clear that 9 or 10 knots an hour at any time or place is excessive speed in a fog. In saying this, I have no doubt that the captain of another steamer like the COLUMBIAN would have gone ahead quite as fast. Had the steamer been an ocean liner instead of a freight steamer it would probably have been sent through the same fog at from 15 to 20 knots an hour, and its captain would have been blamed by his company as well as by his passengers if he had loitered along at half-speed. Though this almost universal practice may relieve the captain of a steamer from moral blame, the captain of the COLUMBIAN was none the less a transgressor of the International Rules and I am bound to find the steamer at fault. I have often had occasion to say that owners and masters must either comply with a law or secure its repeal. Experts may perhaps be found to testify that moderate speed is harmful, a fog-horn useless and a torch misleading, but the statute must be obeyed."—Federal Reporter, No. 91, page 801.

From the decision in the case of the RALEIGH:

"The rule is that such speed only is lawful or moderate speed in a fog as will permit a steamer seasonably and effectually to avoid a collision by slacking her speed or by stopping or reversing within a distance at which another can be seen. If this rule is a severe one and practically requires a steam-ship to come to a stop and remain stopped, when navigating a river having extensive commerce, or in a crowded harbor, it is too well established to be disregarded."—Federal Reporter, No. 44, page 781.

From the decision in the case of the NORMANDIE:

". . . . It is not very material whether her speed was 12 knots or 11.

Either is considerably in excess of what has been adjudged in many cases in the courts of this country an excessive rate of speed in a dense fog. No doubt the question of what is moderate speed is largely a question of circumstances, having reference to the density of the fog; the place of navigation; the probable presence of other vessels likely to be met; the state of the weather as affecting the ability to hear the fog-signals of other vessels at a reasonable distance; the full speed of the ship herself, her appliances for rapid manœuvring, and the amount of her steam-power kept in reserve, as affecting her ability to stop quickly after hearing fog-signals. No doubt also that, in the absence of circumstances of special danger, navigation is not required to be suspended on the high seas on account of dense fog. Neither the rules nor the ordinary practice of seamen require that. The rules intend that signals shall be given which are expected to be heard in time to enable vessels to avoid each other, and no speed is sufficiently moderate under given conditions of wind, sea, and weather, unless it is so reduced as to enable the vessel to perform her duty to keep out of the way, from the time when she has a right to expect that the other vessel's signals, under existing conditions, will be heard.

"There is no case in the country where a speed of two-thirds the maximum speed under such circumstances as the present, has been held to be moderate speed. No doubt certain evolutions could be effected more rapidly with a speed of 10 to 12 knots than with a speed of 6. But a speed of 10 to 12 knots was not more necessary to the NORMANDIE'S safe navigation in this case than was 7 knots in the case of the PENNSYLVANIA. Besides, the question is not whether certain evolutions can be executed in less time, but whether the NORMANDIE, when meeting a vessel suddenly in a fog, could as a rule, more effectively avoid her under a speed of 10 or 12 knots than under a speed of only 6 or 7."—Federal Reporter, No. 43, page 151.

* * * * * * * * * * *

With reference to the practice of the Atlantic liners in keeping up full speed in a fog, and the attempt to justify this on the ground that the time of exposure to danger is thereby lessened, the courts have held that while high-speed under these conditions may be safer for the fast steamers themselves, it is extremely dangerous to any smaller vessels which may be in their track and that it is, therefore, altogether unjustifiable.

An exceptional situation arises when a number of men-of-war are cruising together in formation in a fog. It may reasonably be contended that a somewhat higher speed is necessary for the safe control of a squadron under these conditions than for that of a single ship, and *such speed as can be shown to be actually necessary for safety* is manifestly justified by the phrase in Art. 16, "having careful regard to the existing circumstances and conditions."

The obligation of each ship to keep clear of her neighbors in the squadron is at least as great as the obligation to keep clear of strangers, and anything which can be shown to be *necessary* for this can be justified without placing undue emphasis upon the military features of the situation.

There are no actual decisions by the Courts of this or other countries covering the special case of a vessel encountering a fleet of warships in formation. No doubt such a vessel has all the rights accorded her by the rules of the road as regards each individual vessel of the fleet. But she would do well to remember that each vessel of the fleet has responsibilities (also under the rules of the road) toward every other vessel of the fleet and that, by entering the water of the fleet, she may create a situation of great complexity and serious danger to the ships of the fleet and to herself.

In this connection, the following incident, though not connected with fog, may appropriately find a place here.

Some years ago (1900) the British Channel Fleet of thirty-two ships was proceeding up the English Channel in four columns abreast, when a tug and tow, standing across from starboard to port, and therefore having the right of way, held their course across, and having cleared the first (starboard) column, came into collision with the battleship *Sanspareil,* leading the second column.

It happened that the *Sanspareil* committed a fault which was perfectly evident, and she was very properly condemned for the collision, but the Court, in passing upon the case, took occasion to express the opinion that the tug and tow should never have attempted to cross ahead of the fleet or to pass through it, even though they had technically the right of way over each individual ship.

> **". . . . The ships being in that formation, it is of the utmost importance that perfect order should be preserved because to become disorganized is to run risk of great disaster. . . . . On coming up with a big fleet like that, what ought the tug and tow to have done? Consider what they proposed to do. They proposed to keep a course which would have just cleared them of the first column, which would land them, if the fleet did not stop, in front of the leading ship of the second column, which would carry them into the center of the third column and . . . . into about the center of the fourth column. Consider the danger cast upon the fleet by having its columns broken in such a way, the difficulty of stopping ships of that huge build and weight suddenly and interfering with their course. . . . . I do not see how, without great difficulty and danger, the Channel Fleet could possibly have done so without running great risk of injury to its vessels." From opinion of the Supreme Court of Judicature in the case of the SANSPAREIL, 9 Aspinall, Marine Cases, page 78.**

The following decision in the case of the PATRIA is important in connection with lookouts. There are many other similar decisions:

> **"Besides this, I think the steamer is further to blame for not having a lookout stationed forward at the bow. Nor was the lookout doubled. There was but one seaman acting as lookout, and he was stationed on the bridge, some 75 feet or more from the bow, and was also attending to blowing the whistle once a minute. If on account of the lighter fog above, it was desirable to have a lookout as high above the deck as possible, a lookout might have been stationed in the cross-trees or crow's nest, as is often done in thick fog; but neither that, nor a look-**

out on the bridge, would be a justification of the omission to keep a good lookout at the bow, which it has been repeatedly held should be maintained wherever possible. The master states his opinion, that if he had had 10 seconds more time, the collision would have been avoided. Had a lookout been stationed at the bow with no divided duties, and reported the schooner at the same distance it was seen from the bridge, the steamer would have had much more than this additional time for coming to a complete stop and backing away from the schooner."—Federal Reporter, No. 96, page 411.

NOTE 19.—It should be noted that the *ship* need not be stopped immediately, but the *engines* must be. If, later, the danger appears such that the ship should be stopped, there will be a reserve of steam ready for backing hard. The objection to backing the engines before the location of the danger is fixed, is that by doing so the control of the ship by the helm is to a great extent destroyed.

NOTE 20.—It is clear that this rule could not safely be applied by the individual vessels of a squadron of men-of-war steaming in formation in a fog. Each vessel under such circumstances must have due regard to her neighbors in squadron as well as to other vessels which may be near.

IV.—STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. **If the bearing does not appreciably change**, such risk should be deemed to exist.[21]

NOTE 21.—*The principle involved here is one of such vital importance that it should be very carefully impressed upon all officers.* If the bearing of the other vessel is changing materially, there is no danger of collision. If it is not changing materially, collision is certain to result unless one vessel changes course or speed. The fact that the bearing is not changing indicates that both vessels are due to arrive at the same time at the point where their courses intersect. If either vessel changes course or speed (materially) the danger will be averted. If both vessels change, the danger may remain. It is for this reason that the law provides (Art. 21) that the vessel which has the other on her own port side shall keep her course and speed. Assuming that this requirement is complied with, practically any change on the part of the other vessel should make the situation safe, but the law has wisely provided (Art. 22) that she shall, if possible, avoid crossing ahead.

The practical way to determine whether the bearing is or is not changing, is to stand at a point from which the compass can be watched, and then, taking care that a steady course is steered, bring

the other vessel or light "on" with a point of the rigging or the rail, and watch thus for a change in its bearing.

There are, of course, many cases in which there is no time to wait for a change in bearing; but in cases of such emergency as this, the ships are close enough together to make the danger clear at a glance, and there is rarely more than one course of action that can give a hope of safety.

It is of course not necessary to wait for the side-light of a steamer to show. The masthead light should be visible five miles, and if it shows at anything like this distance the warning of danger, assuming that such exists, will be perfectly clear long before the side-lights are made out.

Sailing-vessels.

Art. 17. When two sailing-vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is close-hauled.

(b) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.[22]

NOTE 22.—These rules are simple and satisfactory when the situations to which they apply are clearly defined. But in practice it is often impossible for *A* to tell with any degree of certainty whether *B* is close-hauled or a little free; and yet the action to be taken by *A* may depend upon this and this alone.

A similar difficulty arises when *A*, running with the wind free on the port hand, sights *B*, to port and running free, and cannot tell on which side *B* has the wind. If she has it on the starboard side, *A* must keep clear, under rule (c); if on the port side, *A* has the right of way and *B* must keep clear under rule (d), because she is to windward of *A*.

No doubt a rational interpretation of this rule would require *B* to keep clear in most of these doubtful cases, on the ground that she would have the wind so nearly aft that it should be considered aft in the meaning of the law.

An officer taking charge of the deck of a sailing ship should estimate carefully the true direction of the wind and consider what conclusions may be based upon this with regard to the possible or probable course of other vessels whose lights may be sighted ahead or on either hand. Remembering that a square rigger can not lie closer to the wind than 6 points and that side-lights show through a range of ten points, from right ahead to two points abaft the beam, he will have much information upon which to base an opinion as to the way in which a ship may be heading which is seen on a given bearing, showing a red or green light. If his own ship is close-hauled on the port tack, he has the right of way over all other vessels except one close-hauled on the starboard tack, and it is clear that such a vessel, to threaten collision, must bear a little on the lee bow and must show a red light. In a similar way, deductions may be drawn from the data available in any given case, and, usually, a line of bearing may be decided upon, with reference to which it may be said that, broadly speaking, it is right to stand on for all *crossing* lights seen on one side of this line, and to give way to all *crossing* lights seen on the other side.

This idea has been worked out very completely and put in convenient form for reference by Captain H. S. Blackburne, in a little pamphlet entitled "Diagrams with explanations illustrating the Rules of the Road for sailing Ships."

Steam-vessels Meeting.

Art. 18. When two steam-vessels are meeting end-on, or nearly end-on, so as to involve risk of collision, **each shall alter her course to starboard,** so that each may pass on the port side of the other.

This article only applies to cases where vessels are meeting end-on, or nearly end-on, in such a manner as to involve the risk of collision, and does not apply to two vessels which must, if both keep on their respective courses pass clear of each other.

The only cases to which it does apply are when each of the two vessels is end-on or nearly end-on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line or nearly in a line with her own; and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course; or by night, to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light, or a

green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.[23]

NOTE 23.—The wording of this article is necessarily somewhat indefinite, and leaves room for a difference in the interpretation of the situation on the part of two vessels approaching each other, "nearly end-on," but not exactly so. If one vessel considers that the situation is a case of "meeting," as here defined, while the other considers it one of "crossing," there may be such a conflict of action between them as will lead to serious danger, especially if it happens that each vessel is, in reality, a little on the starboard bow of the other.

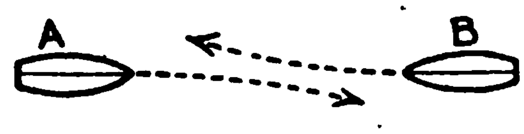
Many seamen consider a green light a very little on the starboard bow the most serious threat of collision with which they have to deal. *The great safeguard, in this and other doubtful cases, lies in an interchange of sound-signals while the vessels are still separated by a safe distance, and in prompt action in accordance with the understanding thus established.*

(For the **sound-signals** to be used in this case under the International Rules, see Art. 28.)

By night there are more chances of dangerous misunderstanding than by day, because of the uncertainty existing on each ship with regard to the exact course of the other, except in cases where both ships are carrying range-lights, which are perhaps more valuable in the situations coming under this article than in any other cases that can arise. Where range-lights are not used, it is imortant to recognize the value of the information given by a **change** in the side-lights seen; as, for example, a change from one light to both, or from both to one. A change in the relative positions of the side-light and the masthead light is also significant, but as there is no means of knowing whether the side-light is forward of the masthead light or abaft it, this gives no information as to the nature of the change of course which is being made.

It should not be forgotten that sound-signals are as applicable by night as by day, and that, under favorable conditions, they can be heard nearly or quite as far as side-lights are required by law to be visible. There is, however, this important difference; that by day the sound of the whistle is usually confirmed by the sight of escaping steam, and seamen commonly rely almost as much upon their eyes as upon their ears for recognizing signals. By night, this advantage does not exist, and greater care is called for. It is especially important to remember that if both vessels whistle at the same instant, neither will hear the other's blast. **Thus, either vessel may think that the other has not signalled at all, or may mistake a two-blast for a one-blast signal.**

Observe that there is nothing in Art. 18 which leaves any choice to meeting vessels with regard to the side on which they shall pass



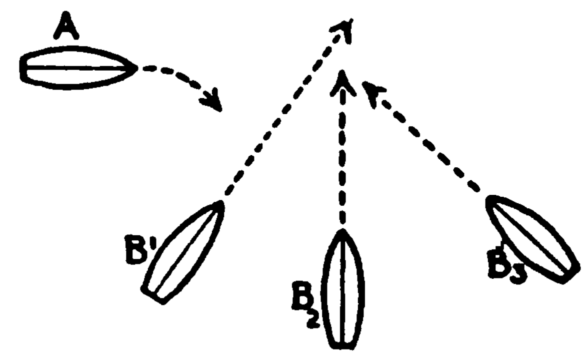
Each vessel puts helm to port and passes with her port side to the other.

Signal Exchanged: One Blast.

Exception. If necessary to pass contrary to this rule (using starboard helm) the proper signal is Two Blasts.

See Article 18, Rules Road, and "Remarks," § VI, Chap. XII.

1. VESSELS MEETING.



A keeps clear and if possible avoids passing ahead of B.

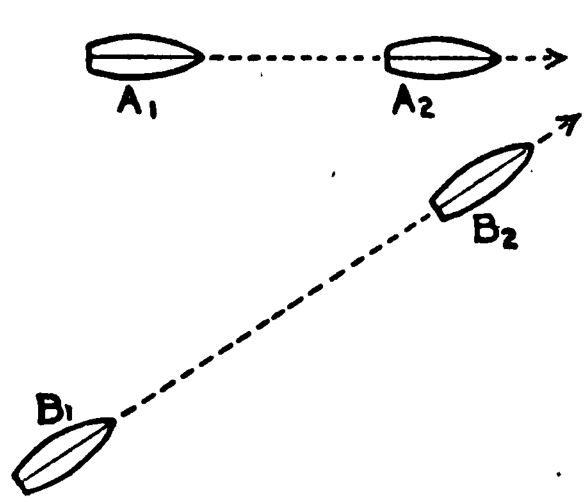
B keeps course and speed.

Signal exchanged; One Blast.

Exception.—If necessary for A to cross ahead, the proper signal is Two Blasts.

See Articles 19, 21, 22, 23. Rules Road; Pilot Rules VIII, IX; "Remarks," § VI, Chap. XII.

2. VESSELS CROSSING.



B has come up from more than 2 pts. abaft A's beam and must keep clear altho' she is on A's starboard hand.

See Art. 24.

3. OVERTAKING.

If B wishes to pass A, she signals with One Blast if wishing to pass to the right, and with Two Blasts if wishing to pass to the left.

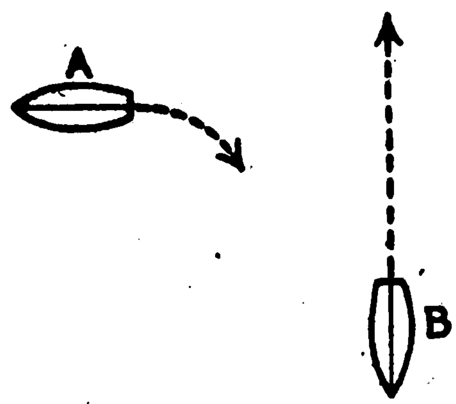
If A consents she answers with the same signal. If she does not consent, she gives several short and rapid blasts.

B must not pass until A consents.

See Rule VIII under Art. 18, U. S. Inland Rules and Note 42 under same Article.

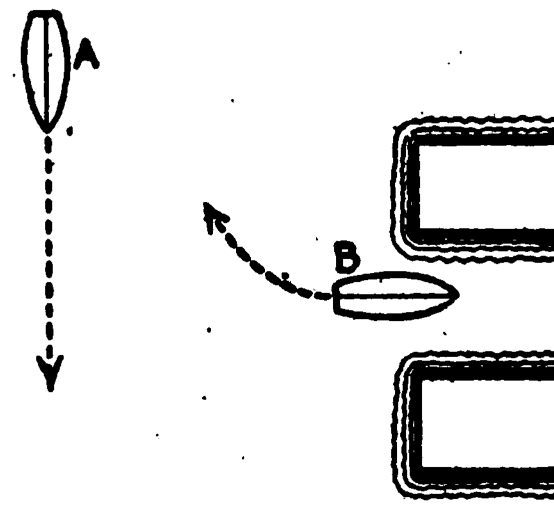
4. PASSING, GOING IN SAME DIRECTION.

TYPICAL SITUATIONS. RULES OF THE ROAD.



Both vessels apply the crossing rule with reference to their direction of motion, so that A keeps clear of B as in Situation 2, Plate 99, and the same whistle signals are exchanged. In this case One Blast.

If it is necessary for A to back across B's line of motion, the proper signal is Two Blasts. See § VI, Chap. XII.



The crossing rule applies as if B's stern were her bow.

B keeps clear.

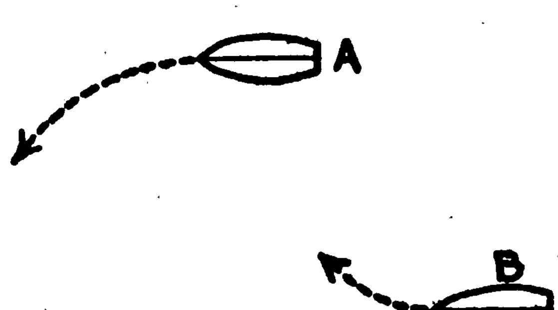
Signal in this case, One Blast

If it is necessary for B to back across A's bow, the proper signal is Two Blasts. Sec. § VI, Chap. XII.

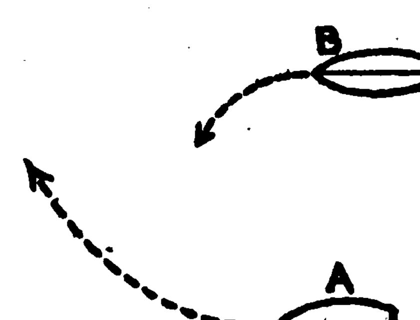
VESSELS CROSSING, BOTH BACKING.

ONE GOING AHEAD, ONE BACKING.

-1.-



-2.-



In these situations, A being presumably faster than B, wishes to cross ahead to make her dock, or for some other reason.

As the two vessels are now on perfectly safe courses, the law does not recognise the right of A to cross, even in Situation 1, where she has B on the port hand.

The following manoeuvres are, however, very common in United States Inland Waters: In 1, A sounds one blast and puts her helm to starboard, B (usually) answers with one blast and takes whatever steps are necessary to keep clear.

In 2, A sounds two blasts and *waits for B to answer*. If B answers with two blasts, A puts her helm to port and crosses, and B takes whatever steps are necessary to keep clear. If, in 2, B does not answer, A (usually) does not cross.

STEAMERS ON PARALLEL COURSES. "A" WISHES TO CROSS AHEAD.

TYPICAL SITUATIONS. RULES OF THE ROAD.

each other. Nevertheless, circumstances sometimes arise in which it is necessary for them to pass starboard to starboard, and this manœuvre can be justified (but only in cases of necessity), under Art. 27. See Note on "Meeting Vessels," § VI of this chapter.

Two Steam-vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, **the vessel which has the other on her own starboard side shall keep out of the way of the other.**"

NOTE 24. —For Sound-Signals to be used by crossing vessels under the International Rules, see Art. 28.

For a discussion of certain points in connection with crossing vessels, see Note 26, under Art. 22.

Steam-vessels shall keep out of the Way of Sailing-vessels.

Art. 20. When a steam-vessel and a sailing-vessel are proceeding in such directions as to involve risk of collision, the steam-vessel shall keep out of the way of the sailing-vessel.

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way **the other shall keep her course and speed.**

Note. When, in consequence of thick weather or other causes, such vessel finds herself so close that collision can not be avoided by the action of the giving-way vessel alone, she also shall take such action as will best aid to avert collision. (See articles twenty-seven and twenty-nine.)"

NOTE. 25.—One of the most trying positions in which an officer can find himself is that of holding on with a prospect of collision where the other vessel ought to keep clear but takes no action to do so. The impossibility of knowing whether the giving-way ship intends to act, and if so when, and the necessity of deciding when the time has come which will justify the holding-on ship in acting under this article make the situation very difficult.

The use of a detonating signal, as per article 12, may be helpful here.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, **avoid crossing ahead of the other.**"

NOTE 26.—This article is one of the most important in the Rules of the Road, to which it was added by the International Conference of 1889.

Taken in connection with Art. 19 and with the new provision of Art. 21, by which the vessel having the right of way is required to keep her speed as well as her course, it defines very clearly the manœuvre for steamers crossing, and requires, as a matter of law, what has always been the practice of careful and competent seamen.

It is manifestly impracticable to insist that the vessel which is required to keep clear shall *never* cross ahead of the other since circumstances may in some cases make it imperative to do so; as, for example, where the vessels suddenly sight each other close aboard, or where neighboring vessels or other dangers must be taken into account. Such situations very rarely arise on the open sea, except in cases of fog, and when they do arise they are fully covered by Art. 21 (International Rules), and Art. 27. It is especially important, in cases of this kind, to indicate by whistle signals the manœuvre which is to be attempted.

In crowded waters, situations frequently arise in which it is essential that the burdened vessel shall cross ahead; but if collision results in such a case, the courts insist upon conclusive evidence that this was in fact the safest course. **Whatever action is to be taken, whether in crowded or in open waters, this action should be announced by the proper whistle signal while the vessels are still at a safe distance.**

It seems to be believed by many officers, that a signal of two blasts by the vessel which should give way has the effect of changing the law and of justifying this vessel in crossing ahead, merely as a matter of convenience. The law on this subject is very clearly set forth in the decisions quoted in §V. of this chapter.

Steam-vessels shall slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these rules every vessel, overtaking any other, shall keep out of the way of the overtaken vessel.[27]

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking ves-

sel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of the way.

NOTE 27.—The rule for overtaking vessels applies to sailing-vessels as well as to steamers, so that a sailing-vessel close-hauled coming up from more than two points abaft the beam of a vessel running free, must keep clear. Moreover, a sailing-vessel overtaking a steamer must keep clear. And this obligation upon the overtaking vessel to keep clear is not modified by any subsequent change in the relative position of the two vessels.

Where the crossing rule and the overtaking rule conflict—that is to say, where one vessel is both overtaking and crossing another, **the overtaking rule prevails,** so that a crossing steamer which has come up from more than two points abaft the beam of another, must keep clear, even though she is on the starboard side of the other; and she is not relieved from this obligation even after she draws ahead on to the beam and bow of the other vessel.

Narrow Channels.

Art. 25. In narrow channels every steam-vessel shall, when it is safe and practicable, keep to that side of the fair-way or mid-channel which lies on the starboard side of such vessel.[a]

NOTE 28.—It is not permissible to keep to the wrong side of the channel to avoid an unfavorable current.

Rights of Way of Fishing-vessels.

Art. 26. Sailing-vessels under way shall keep out of the way of sailing-vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

General Prudential Rule.

Art. 27. *In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.*

Sound-signals for Vessels in Sight of One Another[29]

Art. 28. The words "**short blast**" used in this article shall mean a blast of about one second's duration.

When vessels are in sight of one another, a steam-vessel under way, in taking any course authorized or required by these rules, shall indicate that course by the following signals on her whistle or siren, namely:

One short blast to mean, "**I am directing my course to starboard.**"

Two short blasts to mean, "**I am directing my course to port.**"

Three short blasts to mean, "**My engines are going at full speed astern.**"

NOTE 29.—It should be noted that this rule applies to vessels in sight of each other, whether by night or day, in clear or in foggy weather, but not to vessels, however close, which do not see each other or each other's lights. Thus two vessels in a fog must keep to the signals of Art. 15 until they actually see each other. Many seamen hold that there would be great advantage in the use of these signals by vessels near each other, but not in sight, in a fog, and some officers do not hesitate to use them in this way; but this is in direct defiance of the law.

No Vessel, under any Circumstances, to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by special circumstances of the case.

Reservation of Rules for Harbors and Inland Navigation.

Art. 30. Nothing in these rules shall interfere with the operation of a special rule, duly made by local authority, relative to the navigation of any harbor, river, or inland waters.[30]

NOTE 30.—In the waters of the United States there are two sets of rules "duly made by local authority"; 1st, the so-called "Inland Rules" made by Act of Congress; 2d, the "Pilot Rules" made by the inspectors of steam-vessels, under the provision of Art. 5, section 2 of the Inland Rules. Both of these sets of Rules follow. (§ III and § IV.)

Distress Signals.

Art. 31. When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the daytime—

First. A gun or other explosive signal fired at intervals of about a minute.

Second. The international code signal of distress indicated by N. C.

Third. The distance signal, consisting of a square flag, having either above or below it a ball or anything resembling a ball.

Fourth. A continuous sounding with any fog-signal apparatus.

At night—

First. A gun or other expolsive signal fired at intervals of about a minute.

Second. Flames on the vessel as from a burning tar barrel, oil barrel, and so forth.

Third. Rockets or shells throwing stars of any color or description, fired one at a time, at short intervals.

Fourth. A continuous sounding with any fog-signal apparatus.

§ III.

RULES FOR UNITED STATES INLAND WATERS.

These rules, while in most respects identical with the International Rules, differ from them in some important respects. The points of difference are in most cases indicated by the use of double-spaced type throughout this section.

These rules are supplemented by the Pilot Rules quoted in § IV.

I.—ENACTING CLAUSE, ETC.

AN ACT TO ADOPT REGULATIONS FOR PREVENTING COLLISIONS UPON CERTAIN HARBORS, RIVERS, AND INLAND WATERS OF THE UNITED STATES. APPROVED JUNE 7, 1897.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following regulations for preventing collision shall be followed by all vessels navigating all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal and the Red River of the North and rivers emptying into the Gulf of Mexico and

their tributaries, and are hereby declared special rules duly made by local authority:

NOTE 31.– Other rules are prescribed for the Great Lakes and for the rivers emptying into the Gulf of Mexico. These rules can be obtained from the inspectors of steam-vessels at any custom-house.

Preliminary Definitions.

In the following rules every steam-vessel which is under sail and not under steam is to be considered a sailing-vessel, and every vessel under steam, whether under sail or not, is to be considered a steam-vessel.

The word "steam-vessel" shall include any vessel propelled by machinery.

A vessel is "**under way**," within the meaning of these rules, when she is not at anchor, or made fast to the shore, or aground.

II.—LIGHTS, AND SO FORTH.

The word "visible" in these rules, when applied to lights, shall mean visible on a dark night with a clear atmosphere.

Art. 1. The rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such time no other lights which may be mistaken for the prescribed lights shall be exhibited.

Steam-Vessels—Masthead Light.

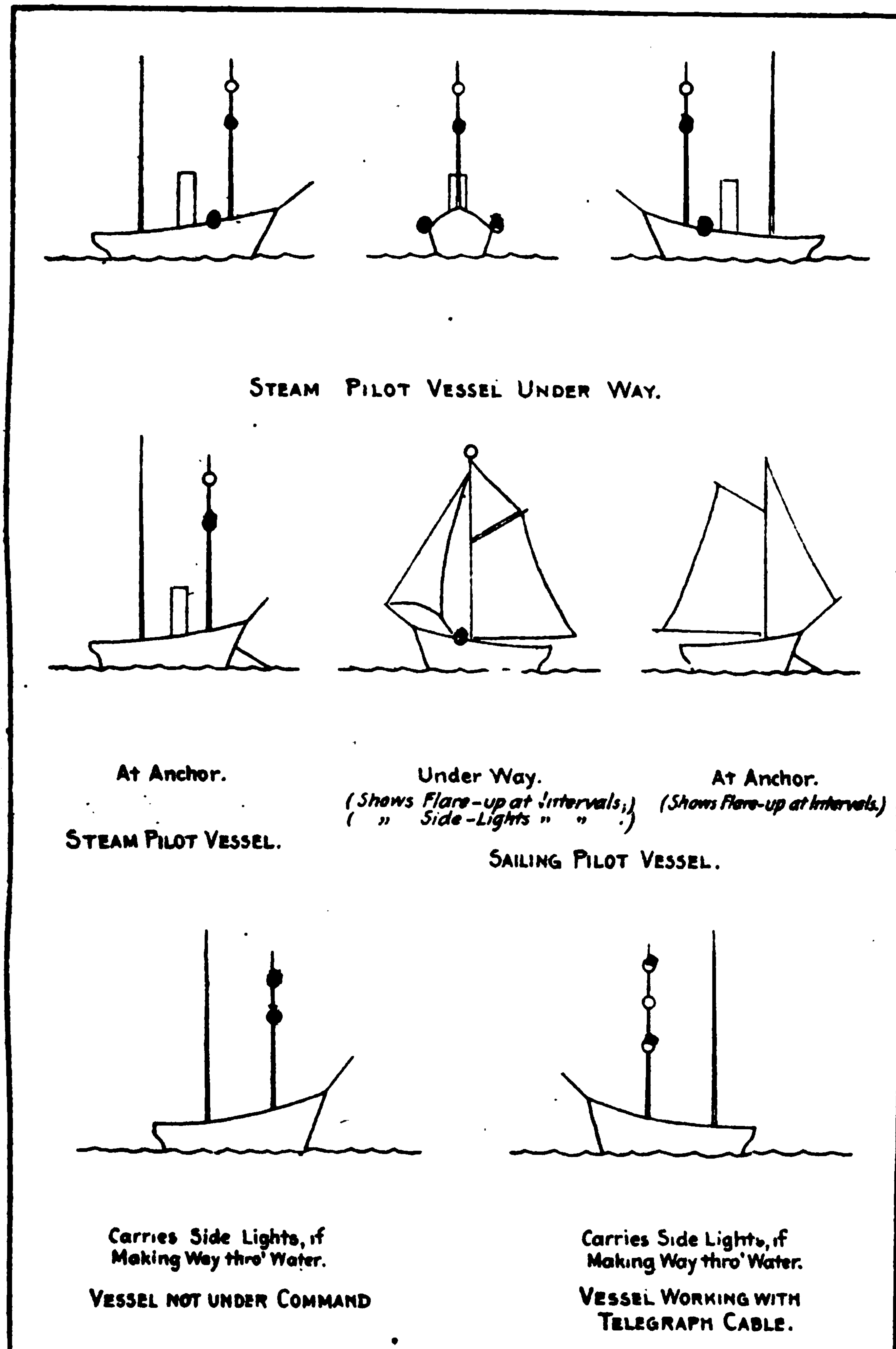
Art. 2. **A steam-vessel** when under way shall carry—(a) *On or in front of the foremast,* or, if a vessel without a foremast, then in the forepart of the vessel, *a bright white light* so constructed as to show an unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the vessel, namely, from right ahead to two points abaft the beam on either side, and of such a character as to be visible at a distance of at least five miles.

Steam-Vessels—Side-Lights.

(b) *On the starboard side a green light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least two miles.

(c) *On the port side a red light* so constructed as to show an unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right ahead to two points abaft the beam on the port side, and of such a character as to be visible at a distance of at least two miles.

Plate No. 101.



VESSELS LIGHTS.

(*Facing page* 368)

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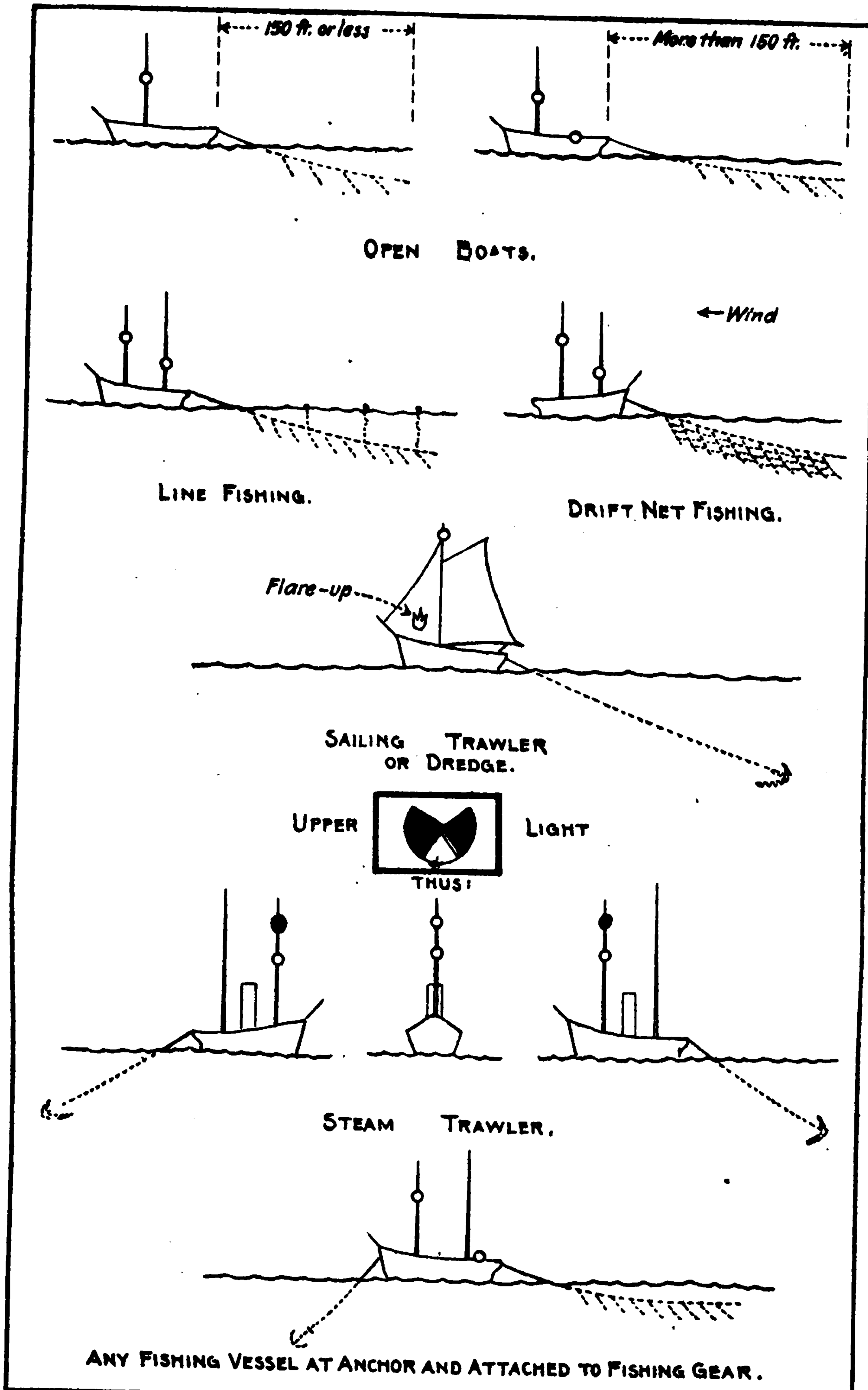


VESSELS LIGHTS.

(Facing page 369)

(d) The said green and red side-lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Steam-Vessels—Range-Lights.

(e) **A sea-going steam-vessel** when under way may carry an *additional white light,* similar in construction to the light mentioned in subdivision (a). These two lights shall be so placed in line with the keel that one shall be at least fifteen feet higher than the other, and in such a position with reference to each other that the lower light shall be forward of the upper one. The vertical distance between these lights shall be less than the horizontal distance.

(f) All steam-vessels (except sea-going vessels and ferry-boats) shall carry in addition to green and red lights required by article two (b), (c), and screens as required by article two (d), a central range of two white lights, the after-light being carried at an elevation at least fifteen feet above the light at the head of the vessel. The head-light shall be so constructed as to show an unbroken light through twenty points of the compass, namely, from right ahead to two points abaft the beam on either side of the vessel, and the after-light so as to show all around the horizon.

Steam-Vessels—When Towing.

Art. 3. A steam-vessel when **towing** another vessel shall, in addition to her side-lights, carry *two bright white lights* in a vertical line, one over the other, not less than three feet apart, and when towing more than one vessel, shall carry an additional bright white light three feet above or below such lights, if the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds six hundred feet. Each of these lights shall be of the same construction and character, and shall be carried in the same position as the white light mentioned in article two (a) or the after range-light mentioned in article two (f).

Such steam-vessel may carry a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light shall not be visible forward of the beam.

Note 32.—The following lights are carried by barges and canal-boats in tow: "In the Hudson River, the East River and Long Island Sound, to and including Narragansett Bay, barges and canal-boats carry white lights at bow and stern. Where a number of them are massed in one or more tiers, the limits of the tow are marked by

white lights carried at the bows of the outside boats and an additional white light at the stern of each of the two outside boats of the last tier."

In waters other than those above-named, barges and canal-boats in tow carry colored side-lights; and where they are massed in tiers, these lights are carried at the bows of the outside barges of each tier.

Ferry-boats carry the side-lights and range-lights of other steamers except that double-ended ferry-boats carry a *central range of white lights* showing all around the horizon and placed *at equal heights* forward and aft; in place of the range-lights of other vessels.

In addition to the above, ferry-boats may carry a special light, white or colored, on a flag-staff amidships, 15 feet above the white range-lights, for the purpose of distinguishing different lines of ferry-boats from each other.

NOTE 33.—Art. 4 of the International Rules is omitted from the Inland Rules. In inland waters, therefore, a vessel not under command and a vessel laying or picking up a telegraph cable, carry the same lights as other vessels.

Lights for Sailing-Vessels and Vessels in Tow.

Art. 5. **A sailing-vessel under way or being towed** shall carry the same lights as are prescribed by article two for a steam-vessel under way, with the exception of the white lights mentioned therein, which they shall never carry.

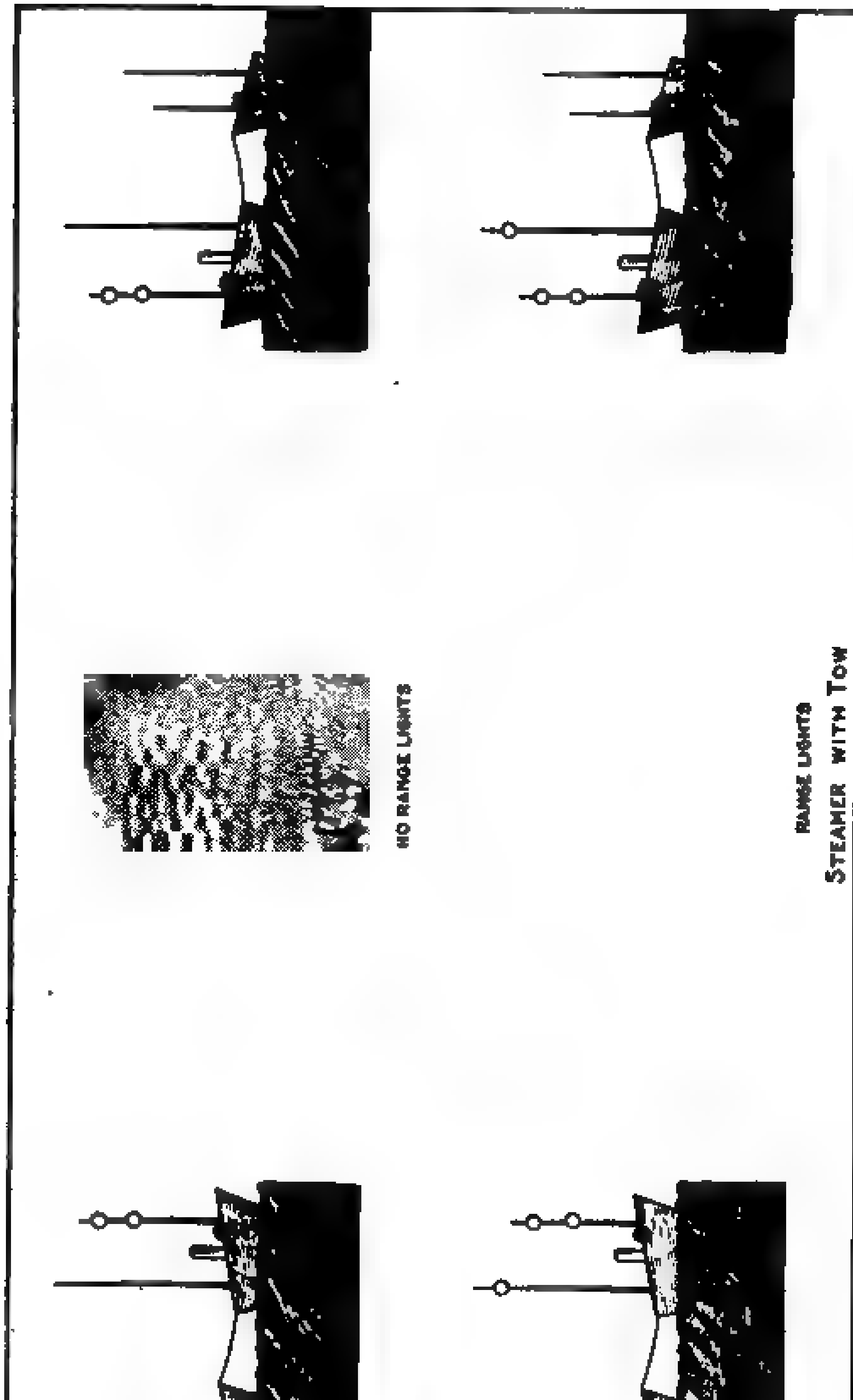
NOTE 34.—No lights are prescribed for steam-vessels being towed in inland waters. Such vessels, however, carry the same lights as sailing-vessels being towed.

Lights for Ferry-Boats, Barges, and Canal-Boats in Tow.

Sec. 2. That the supervising inspectors of steam-vessels and the Supervising Inspector-General shall establish such rules to be observed *by steam-vessels in passing each other,* and as to the lights to be carried by ferry-boats and by barges and canal-boats when in tow of steam-vessels, not inconsistent with the provisions of this Act, as they from time to time may deem necessary for safety, which rules, when approved by the Secretary of the Treasury, are hereby declared special rules duly made by local authority, as provided for in article thirty of chapter eight hundred and two of the laws of eighteen hundred and ninety. Two printed copies of such rules shall be furnished to such ferry-boats and steam-vessels, which rules shall be kept posted up in conspicuous places in such vessels.

NOTE 35.—Under the authority of Sec. 2, Art. 5, the **supervising** inspectors of steam-vessels issue from time to time a pamphlet entitled "**PILOT RULES FOR THE INLAND WATERS OF THE**

Plate No. 103.



VESSELS TOWING WITH AND WITHOUT RANGE LIGHTS.

(Facing page 370)

Lights for Steam Pilot-Vessels.

A steam pilot-vessel, when engaged on her station on pilotage duty and in waters of the United States, and *not at anchor,* shall, in addition to the lights required for all pilot-boats, carry at a distance of eight feet below her white masthead light a *red light,* visible all around the horizon and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles, and also the colored *side-lights* required to be carried by vessels when under way.

When engaged on her station on pilotage duty and in waters of the United States, and *at anchor,* she shall carry in addition to the lights required for all pilot-boats the *red light* above-mentioned, but not the colored side-lights.

When not engaged on her station on pilotage duty, she shall carry the same lights as other steam-vessels.

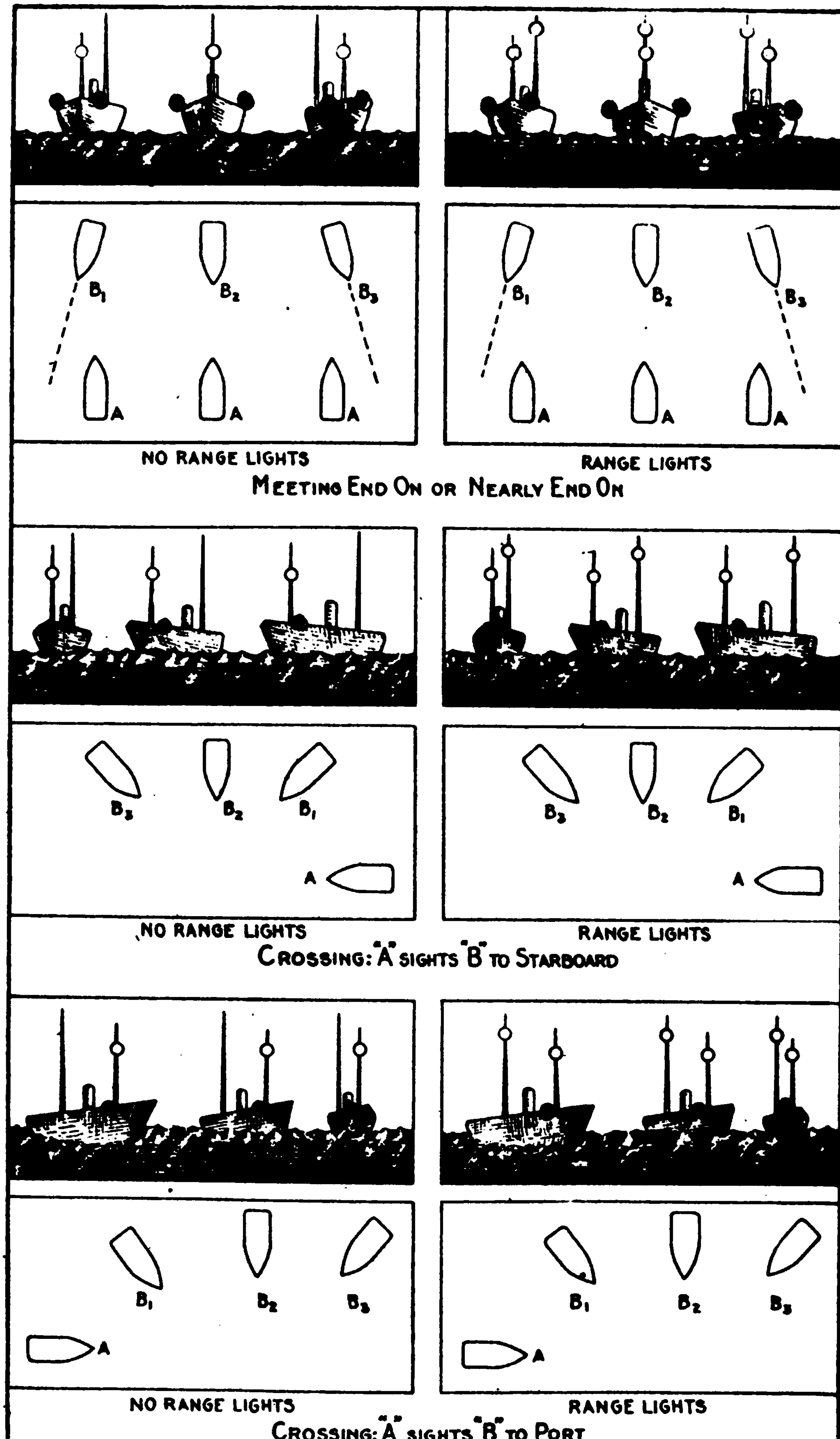
Lights, Etc., of Fishing-Vessels.

Art. 9. (a) Fishing-vessels of less than ten gross tons, when under way and when not having their nets, trawls, dredges, or lines in the water, shall not be obliged to carry the colored side-lights; but every such vessel shall, in lieu thereof, have ready at hand a lantern with a green glass on one side and a red glass on the other side, and on approaching to or being approached by another vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

(b) All fishing-vessels and fishing-boats of ten gross tons or upward, when under way and when not having their nets, trawls, dredges, or lines in the water, shall carry and show the same lights as other vessels under way.

(c) All vessels, when **trawling, dredging, or fishing with any kind of drag-nets or lines,** shall exhibit, from some part of the vessel where they can be best seen, *two lights.* One of these lights shall be *red* and the other shall be *white.* The red light shall be *above the white light,* and shall be at a vertical distance from it of not less than six feet and not more than twelve feet; and the horizontal distance between them, if any, shall not be more than ten feet. These two lights shall be of such a character and contained in lanterns of such construction as to be visible all round the horizon, the white light a distance of not less than three miles and the red light of not less than two miles.

Plate No. 104.



STEAMERS MEETING AND CROSSING WITH AND WITHOUT RANGE-LIGHTS.

(Showing B as seen by A.)

(*Facing page* 372)

Lights for Rafts or Other Craft Not Provided For.

(d) Rafts, or other water craft not herein provided for, navigating by hand-power, horse-power, or by the current of the river, shall carry one or more good white lights, which shall be placed in such manner as shall be prescribed by the Board of Supervising Inspectors of Steam Vessels.

Lights for an Overtaken Vessel.

Art. 10. A vessel which is being **overtaken** by another, except a steam-vessel with an after range-light showing all around the horizon, shall show from her stern to such last-mentioned vessel a *white light or a flare-up light.*

Anchor Lights.

Art. 11. A vessel under one hundred and fifty feet in length **when at anchor** shall carry forward, where it can *best be* seen, but at a height not exceeding twenty feet above the hull, a *white light,* in a lantern so constructed as to show a clear, uniform, and unbroken light visible all around the horizon at a distance of at least one mile.

A vessel of one hundred and fifty feet or upwards in length when at anchor shall carry in the forward part of the vessel, at a height of not less than twenty and not exceeding forty feet above the hull, *one such light,* and at or near the stern of the vessel, and at such a height that it shall be not less than fifteen feet lower than the forward light, *another such light.*

The length of a vessel shall be deemed to be the length appearing in her certificate of registry.

NOTE 36.—As the Inland Rules do not prescribe special lights for a vessel aground, such a vessel must, in United States inland waters, show the lights of a vessel at anchor.

Special Signals.

Art. 12. Every vessel may, if necessary, in order to attract attention, in addition to the lights which she is by these rules required to carry, show a *flare-up* light or use any detonating signal that can not be mistaken for a distress signal.

Naval Lights and Recognition Signals.

Art. 13. Nothing in these rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for two or more ships of war or for vessels sailing under convoy, or with the

exhibition of recognition signals adopted by shipowners, which have been authorized by their respective Governments, and duly registered and published.

Steam-Vessels Under Sail by Day.

Art. 14. A steam-vessel proceeding under sail only, but having her funnel up, may carry in day-time, forward, where it can best be seen, one black ball or shape two feet in diameter.

III.—SOUND SIGNALS FOR FOG, AND SO FORTH.

Preliminary.

Art. 15. All signals prescribed by this article for vessels under way shall be given:

1. By "steam-vessels" on the whistle or siren.
2. By "sailing-vessels" and "vessels towed" on the fog-horn.

The words "prolonged blast" used in this article shall mean a blast *of from four to six seconds duration.*

A steam-vessel shall be provided with an efficient whistle or siren, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog-horn; also with an efficient bell. A sailing-vessel of twenty tons gross tonnage or upward shall be provided with a similar fog-horn and bell.

In fog, mist, falling snow, or heavy rainstorms, whether by day or night, the signals described in this article shall be used as follows, namely:

Steam-Vessels Under Way.

(a) A steam-vessel **under way** shall sound, at intervals of not more than **one** minute, *a prolonged blast.*

NOTE 37.—In United States inland waters no special signal is provided for a vessel *under way, but having no way upon her.* Such a vessel uses the regular signal for a vessel under way.

Sail-Vessels Under Way.

(c) **A sailing-vessel** under way shall sound, at intervals of not more than **one** minute, when on the *starboard tack, one blast;* when on the *port tack, two blasts* in succession, and when with the *wind abaft the beam, three blasts* in succession.

Vessels at Anchor.

(d) A vessel when **at anchor** shall, at intervals, of not more than one minute, *ring the bell rapidly for about five seconds.*

Plate No. 105.

FOG SIGNALS.

——— LONG BLAST. — SHORT BLAST.

STEAM VESSEL HAVING WAY UPON HER	———
STEAM VESSEL UNDERWAY BUT STOPPED and HAVING NO WAY UPON HER	——— 1 Second Interval ———
SAILING VESSEL UNDERWAY	
On Starboard Tack	———
On Port Tack	——— ———
With Wind Abaft Beam	——— ——— ———
VESSEL TOWING VESSEL TOWED VESSEL NOT UNDER COMMAND VESSEL WORKING WITH TELEGRAPH CABLE	——— — —

NOTE.—The International Rules require the above signals to be sounded at intervals not exceeding 2 minutes, the United States Inland Rules at intervals not exceeding 1 minute.

VESSEL AT ANCHOR	Ring BELL rapidly for 5 seconds (at intervals of 1 minute).
VESSEL FISHING	——— (Blast) Ring Bell.

SOUND SIGNALS.

FOR VESSELS IN SIGHT OF EACH OTHER.

—	I am directing my course to starboard.
— —	I am directing my course to port.
— — —	My engines are going Full Speed Astern.

NOTE.—The significance attached to these signals in the Pilot Rules for United States Inland waters is slightly different from the above.

(See Note 48, Chapter xii, Section iv.)

Vessels Towing or Towed.

(e) A *steam*-vessel when **towing**, shall, instead of the signals prescribed in subdivision (a) of this article, at intervals of not more than **one** minute, sound *three blasts in succession, namely, one prolonged blast followed by two short blasts.*

A vessel towed may give this signal and she shall not give any other.

NOTE 38.—In United States inland waters no signal is provided for a vessel *not under command.*

Rafts or Other Craft Not Provided For.

(f) All rafts or other water craft, not herein provided for, navigating by hand-power, horse-power, or by the current of the river, shall sound a blast of the fog-horn, or equivalent signal, at intervals of not more than one minute.

Speed in Fog.

Art. 16. Every vessel shall, in a fog, mist, falling snow, or heavy rainstorms, go at a **moderate speed,** having careful regard to the existing circumstances and conditions.

A steam-vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

NOTE 39.—See the very full discussion of **Speed in a Fog** in Note 18 under Art. 16 of the International Rules.

IV.—STEERING AND SAILING RULES.

Preliminary—Risk of Collision.

Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

NOTE 40.—See Note 21 under corresponding paragraph in the International Rules.

Sailing-Vessels Meeting or Crossing.

Art. 17. When two sailing-vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows, namely:

(a) A vessel which is running free shall keep out of the way of a vessel which is close-hauled,

(b) A vessel which is close-hauled on the port tack shall keep out of the way of a vessel which is close-hauled on the starboard tack.

(c) When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.

(d) When both are running free, with the wind on the same side, the vessel which is to the windward shall keep out of the way of the vessel which is to *the* leeward.

(e) A vessel which has the wind aft shall keep out of the way of the other vessel.

Steam-Vessels Meeting.

NOTE 41.—The Inland Rules for steam-vessels meeting and crossing, while identical in their general features with the International Rules, are modified in some respects by the *Pilot Rules* established by the supervising inspectors of steam-vessels and set forth in § IV of the present chapter.

Art. 18. Rule I. When steam-vessels are approaching each other **head and head**, that is, end on, or nearly so, it shall be the duty of each to pass on the port side of the other; and either vessel shall give, as a signal of her intention, *one short and distinct blast* of her whistle, which the other vessel shall answer promptly by a similar blast of her whistle, and thereupon such vessels shall pass on the port side of each other. But if the courses of such vessels are so far on the starboard of each other as not to be considered as meeting head and head, either vessel shall immediately give *two short and distinct blasts of her whistle*, which the other vessel shall answer promptly by two similar blasts of her whistle, and they shall pass on the starboard side of each other.

The foregoing only applies to cases where vessels are meeting end on or nearly end on, in such a manner as to involve risk of collision; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own, and by night to cases in which each vessel is in such a position as to see both the side-lights of the other.

It does not apply by day to cases in which a vessel sees another ahead crossing her own course, or by night to cases where the red light of one vessel is opposed to the red light of the other, or where the green light of one vessel is opposed to the green light of the other, or where a red light without a green light or a green light without a red light, is seen ahead, or where both green and red lights are seen anywhere but ahead.

The Danger Signal.

Rule III. If, when steam-vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving **several short and rapid blasts**, not less than four, of the steam-whistle.

Nearing a Bend or Leaving a Slip.

Rule V. Whenever a steam-vessel is **nearing a short bend or curve in the channel**, where, from the height of the banks or other cause, a steam-vessel approaching from the opposite direction can not be seen for a distance of half a mile, such steam-vessel, when she shall have arrived within half a mile of such curve or bend, shall give a signal by **one long blast** of the steam-whistle, which signal shall be answered by a similar blast, given by any approaching steam-vessel that may be within hearing. Should such signal be so answered by a steam-vessel upon the farther side of such bend, then the usual signals for meeting and passing shall immediately be given and answered; but, if the first alarm signal of such vessel be not answered, she is to consider the channel clear and govern herself accordingly.

When steam-vessels are **moved from their docks or berths**, and other boats are liable to pass from any direction toward them, they shall give the *same signal as in the case of vessels meeting at a bend*, but immediately after clearing the berths so as to be fully in sight they shall be governed by the steering and sailing rules.

Passing a Vessel Going in Same Direction.

Rule VIII. When steam-vessels are running in the same direction, and the vessel which is astern shall desire **to pass on the right** or starboard hand of the vessel ahead, she shall give *one short blast* of the steam-whistle, as a signal of such desire, and if the vessel ahead answers with one blast, she shall put her helm to port; or if she shall desire **to pass on the left** or port side of the vessel ahead, she shall give *two short blasts* of the steam-whistle as a signal of such desire, and if the vessel ahead answers with two blasts, shall put her helm to starboard; or if the vessel ahead does not think it safe for the vessel astern to attempt to pass at that point, she shall immediately signify the same by giving *several short and rapid blasts* of the steam-whistle, not less than four, and under no circumstances shall the vessel astern attempt to pass the vessel ahead until such time as they have reached a point where it can be safely done, when said vessel ahead shall signify her willingness by blowing the proper signals. The vessel ahead shall in no case attempt to cross the bow or crowd upon the course of the passing vessel.

NOTE 42.—It is good seamanship for a vessel overtaking another from directly astern and desiring to pass her, to pass to the left rather than to the right, and for the following reason: Suppose that *A* is overtaking *B*. It may happen that while *A* is passing, *B* will meet another vessel, *C*. In this case, *B* must put her helm to port and sheer over to the right, which will throw her directly across *A's* bow if *A* is passing on that side. With *A* passing on the other side, *B's* port helm will take her clear of both *A* and *C*.

Rule IX. The whistle signals provided in the rules under this article, for steam-vessels meeting, passing, or overtaking, are never to be used except when steamers are in sight of each other, and the course and position of each can be determined in the day-time by a sight of the vessel itself, or by night by seeing its signal lights. In fog, mist, falling snow or heavy rainstorms, when vessels can not so see each other, fog-signals only must be given.

Two Steam-Vessels Crossing.

Art. 19. When two steam-vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

NOTE 43.—In connection with Arts. 19, 21, 22 and 23, see **Pilot Rules,** § IV of this chapter; see also "**Remarks on Vessels Meeting and Crossing.**" § VI.

Steam-Vessels Shall Keep Out of the Way of Sailing-Vessels.

Art. 20. When a steam-vessel and a sailing-vessel are proceeding in such directions as to involve risk of collision, the steam-vessel shall keep out of the way of the sailing-vessel.

Course and Speed.

Art. 21. Where, by any of these rules, one of the two vessels is to keep out of the way the other shall keep her course and speed.

Crossing Ahead.

Art. 22. Every vessel which is directed by these rules to keep out of the way of another vessel shall, if the circumstances of the case admit, avoid crossing ahead of the other.

Steam-Vessel Shall Slacken Speed or Stop.

Art. 23. Every steam-vessel which is directed by these rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Overtaking Vessels.

Art. 24. Notwithstanding anything contained in these rules every vessel overtaking any other, shall keep out of the way of the overtaken vessel.

Every vessel coming up with another vessel from any direction more than two points abaft her beam, that is, in such a position, with reference to the vessel which she is overtaking that at night she would be unable to see either of that vessel's side-lights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these rules, or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear.

As by day the overtaking vessel can not always know with certainty whether she is forward of or abaft this direction from the other vessel she should, if in doubt, assume that she is an overtaking vessel and keep out of her way.

NOTE 44.—See Note 27 under Article 24, International Rules.

In cases where the crossing rule and the overtaking rule conflict, the overtaking rule prevails; so that a vessel which is both overtaking and crossing another must keep clear, even though she has the other on her port hand.

Narrow Channels.

Art. 25. In narrow channels every steam-vessel shall, when it is safe and practicable, keep to that side of the fair-way or mid-channel which lies on the starboard side of such vessel.

NOTE 45.—It is not permissible to keep to the wrong side of the channel either to avoid an unfavorable tide or for any other purpose. See Note 46.

Rights of Way of Fishing-Vessels.

Art. 26. Sailing-vessels under way shall keep out of the way of sailing-vessels or boats fishing with nets, or lines, or trawls. This rule shall not give to any vessel or boat engaged in fishing the right of obstructing a fair-way used by vessels other than fishing-vessels or boats.

General Prudential Rule.

Art. 27. In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances which may render a departure from the above rules necessary in order to avoid immediate danger.

NOTE 46.—Although there is no provision of the law giving special privileges to ferry-boats the courts have repeatedly held that ferry-boats are entitled to reasonable freedom of entrance to, and exit from, their slips.

It is generally held, also, that vessels navigating a harbor should avoid passing close to the docks.

By a special statute of the State of New York, vessels navigating East River are required to keep as near the middle of the stream as is practicable, and not to exceed a speed of 10 knots.

Sound-Signals for Vessels in Sight of One Another.

Art. 28. When vessels are in sight of one another a steam-vessel under way whose engines are going at full speed astern shall indicate that fact by three short blasts on the whistle.

NOTE 47.—Compare with Art. 28 of the International Rules.

Observe that no sound-signals are given here for changing course to port or starboard or for indicating the manœuvre proposed for keeping clear. Such sound-signals are prescribed in the *Pilot Rules.* See § IV of this chapter.

No Vessel Under Any Circumstances to Neglect Proper Precautions.

Art. 29. Nothing in these rules shall exonerate any vessel, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Lights on Naval and Revenue Vessels.

Art. 30. The exhibition of any light on board of a vessel of war of the United States or a revenue cutter may be suspended whenever, in the opinion of the Secretary of the Navy, the commander-in-chief of a squadron, or the commander of a vessel acting singly, the special character of the service may require it.

Distress Signals.

Art. 31 When a vessel is in distress and requires assistance from other vessels or from the shore the following shall be the signals to be used or displayed by her, either together or separately, namely:

In the Daytime.

A continuous sounding with fog-signal apparatus, *or firing a gun.*

At Night.

First. Flames on the vessel as from a burning tar barrel, oil barrel and so forth.

Second. A continuous sounding with any fog-signal apparatus, *or firing a gun.*

§ IV.

PILOT RULES FOR THE INLAND WATERS OF THE ATLANTIC AND PACIFIC COASTS.

The following are the rules established by the Supervising inspectors of steam-vessels, under the authority of Section 2, Article 5 of the United States Inland Rules.

These rules are changed from time to time, but their essential principles can not change, since these must be consistent with the Inland Rules established by law of Congress. The following extracts are from the edition of the rules in force in 1910.

Only those rules are quoted which are important for the present purpose.

Pilot Rule I. The Danger Signal.

If, when steam-vessels are approaching each other, either vessel fails to understand the course or intention of the other, from any cause, the vessel so in doubt shall immediately signify the same by giving several short and rapid blasts, not less than four, of the steam-whistle.

Whenever the danger signal is given the engines of *both steamers shall be stopped and backed* until the headway of the steamers has been fully checked; nor shall the engines of either steamer be again started ahead until the steamers can safely pass each other, and the proper signals for passing have been given, answered, and understood.

Pilot Rule II. Cross Signals.

Steam-vessels are forbidden to use what has become technically known among "pilots" as "*Cross Signals,*" that is, answering one whistle with two and answering two whistles with one. In all cases and under all circumstances, a pilot receiving either of the whistle signals provided in the rules, which for any reason he deems injudicious to comply with, instead of answering it with a cross signal, shall at once sound the danger signal and observe the rule applying thereto (Pilot Rule I).

Pilot Rule III. The Signals for Passing.

The signals for passing, by the blowing of the whistle, shall be given and answered by pilots, in compliance with these rules, not only when meeting "head and head," or nearly so, but at all times, when the steam vessels are in sight of each other, when passing or meeting at a distance within half a mile of each other, and whether passing to the starboard or port.

Pilot Rule IV. Steam-Vessels Meeting.

See Rule I, Art. 18, of the Inland Rules.

Pilot Rule V. Rounding a Bend, or Leaving a Slip.

See Rule V, Art. 18, of the Inland Rules.

Pilot Rule VI. Passing a Vessel Going in Same Direction.

See Rule VIII, Art. 18, of the Inland Rules.

Pilot Rule VII. Passing Hell Gate.

WHEN TWO STEAMERS ARE APPROACHING THE NARROWS KNOWN AS "HELL GATE," on the East River at New York, side by side, or nearly so, running in the same direction, the steamer on the right or starboard hand of the other (when approaching from the west), when they shall have arrived abreast of the north end of Blackwells Island, shall have the right of way, and the steamer on the left or port side shall check her way and drop astern. In like case when two steamers are approaching from the east, and are abreast of Sunken Meadows, the steamer on the right or starboard hand of the other shall have the right of way, and shall proceed on her course without interference, and the steamer on the port side of the other shall keep at a safe distance astern (not less than three lengths) until both steamers have passed through the difficult channel.

Pilot Rule VIII. Steamers Crossing (a).

When two steamers are *approaching each other at right angles or obliquely so as to involve risk of collision,* other than when one steamer is overtaking another, the steamer which has the other on her own port side shall hold her course and speed; and the steamer which has the other on her own starboard side shall keep out of the way of the other by directing her course to starboard so as to cross the stern of the other steamer, or, if necessary to do so, slacken her speed or stop or reverse. The steamer having the other on her own port bow shall blow one blast of her whistle as a signal of her intention to cross the bow of the other, holding her course and speed, which signal shall be promptly answered by the other steamer by one short blast of her whistle as a signal of her intention to direct her course to starboard so as to cross the stern of the other steamer or otherwise keep clear.

If from any cause whatever the conditions covered by this situation are such as to prevent immediate compliance with each other's signals, the misunderstanding or objection shall at once be made apparent by blowing the danger signal, and both steamers shall be stopped, and backed if necessary, until signals for passing with safety are made and understood.

Pilot Rule IX. Steamers Crossing (b).

When two steamers are *approaching each other at right angles or obliquely,* other than when one steamer is overtaking another, so that the steamer having the other on her own starboard side may cross the bow of the other *without involving risk of collision,* the steamer having the other on her own *starboard* side may cross the bow of the other. If the steamers are within half a mile of

each other the steamer having the other on her own starboard side shall give, as a signal of her intention to cross the bow of the other, two short and distinct blasts of her whistle, which, if assented to, the other steamer shall promptly answer by two similar blasts of her whistle, when the steamer having the other on her own starboard bow may cross the bow of the other, in which case the steamer having the other on her own port side shall keep out of the way of the other. If, however, the steamer having the other on her own port side deems it dangerous for the other steamer to cross her bow, she shall sound the danger signal, in which case both steamers shall be stopped, and backed if necessary, until signals for passing with safety are made, answered and understood. (See remark on this Rule in § VI.)

NOTE 48.—It will be seen that the significance attached to the whistle signals of one-blast and two-blasts in these rules is somewhat different from that assigned to them in the International Rules (Art. 28), where they mean "I am directing my course to port," and "I am directing my course to starboard." In Pilot Rules VIII and IX above, one whistle means, when sounded by the vessel having the other on her own starboard hand, "I intend to pass astern of you"; and two blasts, "I think I can safely cross ahead of you, and will do so if you assent." *In these and in other cases, however, one blast does in general call for port helm and two blasts for starboard helm.*

§ V.

RULES FOR VESSELS PASSING DREDGES AT WORK IN CHANNELS.

The improvement of channels in United States waters is done by the Corps of Engineers of the United States Army, and the Secretary of War is authorized to make regulations to be observed by vessels passing dredges or other craft engaged in such improvement.

EXTRACT FROM THE RIVER AND HARBOR ACT OF AUGUST 18, 1894.

SECTION 4. [As amended by Section 11 of the river and harbor Act of June 13, 1902.] That it shall be the duty of the Secretary of War to prescribe such rules and regulations for the use, administration, and navigation of any or all canals and similar works of navigation that now are, or that hereafter may be, owned, operated, or maintained by the United States as in his judgment the public necessity may require; and he is also authorized to prescribe regulations to govern the speed and movement of vessels and other water craft in any public navigable channel which has been improved under authority of Congress, whenever, in his judgment, such regulations are necessary to protect such improved channels from injury, or to prevent interference with the operations of the United States in improving navigable waters or

injury to any plant that may be employed in such operations. Such rules and regulations shall be posted, in conspicuous and appropriate places, for the information of the public; and every person and every corporation which shall violate such rules and regulations shall be deemed guilty of a misdemeanor and, on conviction thereof in any district court of the United States within whose territorial jurisdiction such offense may have been committed, shall be punished by a fine not exceeding five hundred dollars, or by imprisonment (in the case of a natural person) not exceeding six months, in the discretion of the court.

Rules are drawn up for each individual situation coming under the above law, and different sets of rules may differ from each other in minor particulars, but the points covered are practically identical in all cases, and these points are illustrated in the following typical set of rules:

1. Steamers without tows passing the dredges, shall not have a speed greater than six miles an hour, and their propelling machinery shall be stopped when immediately abreast of the dredges, and while passing over the breast and quarter lines of the dredges.

Steamers with tows passing the dredges shall not have a speed greater than six miles an hour, and their propelling machinery shall be stopped while passing over the breast and quarter lines of the dredges; but they may start their propelling machinery if necessary between these lines.

2. Vessels using the channel shall pass the dredges on the side designated from the dredge by the signals prescribed in paragraph 7 of these regulations.

3. Vessels whose draft permits must keep outside of the buoys marking the ends of mooring lines of dredges.

4. Vessels must not anchor on the ranges of stakes or other marks placed for the guidance of the dredges.

5. Vessels must not run over or disturb stakes or other marks placed for the guidance of dredges.

6. Dredges and operating plant, in the prosecution of the work, must not obstruct any part of the channel unnecessarily.

7. Dredges shall display by day a black ball three (3) feet in diameter at the end of a horizontal spar extending to the line of the side of the dredge's hull, and at a height not less than thirty (30) feet above the water, the ball to be set on the side of the dredge on which it is desired approaching vessel shall pass.

> NOTE.—A red flag or other signal may be substituted for the black ball of this paragraph.

Dredges shall display by night one white light on a staff in the middle of the dredge, and at least thirty (30) feet above the water, to serve as the regulation anchor light, and four (4) red lights suspended in a vertical line from the outer end of the horizontal spar

used by day for the suspension of the black ball, the lights to be set on the side of the dredge on which it is desired approaching vessels shall pass. If approaching vessels may pass on either side of the dredge, no day mark shall be displayed, and by night the four red lights shall be displayed in a vertical line directly under the above-mentioned white light.

8. The breast and stern anchors of the dredges shall be marked or buoyed so as to be plainly visible to passing vessels.

9. While vessels in the channel are passing, all lines running across the channel from the dredge on the passing side must be entirely slacked.

10. Dredges will slack the lines referred to in paragraph 9 upon signal by whistle from an approaching vessel.

In addition to the authority vested in the Secretary of War to make regulations as above, the same official is empowered to regulate all other matters which have to do with possible obstructions to navigable waters; such as the dumping of ashes, garbage, etc.; the marking of wrecks and their removal; the building of bridges across navigable channels, and the handling of draws in bridges spanning such channels.

§ VI.

REMARKS ON THE RULES FOR STEAMERS MEETING AND CROSSING.

The rules for meeting and crossing are laid down in Articles 18, 19, 21, 22, 23, 24, 25, 27, and 28 of both the International and Inland Rules and, as regards United States inland waters, in Pilot Rules IV VIII, and IX.

GENERAL PRINCIPLES. All of the above rules are based upon one very simple principle, which is that every steamer in passing another steamer, whether in meeting or in crossing, MUST KEEP TO THE RIGHT; or, in other words, must present her own port side to the vessel which she is passing.

It follows that, if A and B are crossing and if A is already presenting her port side to B, she has no occasion to make a change. She therefore keeps her course and speed. It follows equally that B, since she is presenting her starboard side to A, must make a change, and this change must be of such a nature as to bring her port side toward A. This will, in general call for port helm and will swing B's head toward A's stern, although B may, of course, bring about the same result by slowing, stopping, or backing, thus allowing A to draw ahead across B's bow and toward B's port side.

If the vessels are meeting end-on, neither one is presenting her port side to the other, and each must change course to starboard, thus bringing her port side toward the other.

With regard to SOUND-SIGNALS, it is important to note that any vessel which proposes to comply with the rule as laid down above, by passing with her port side toward the other vessel, uses a signal of one blast.

IT IS ONLY WHEN GOING CONTRARY TO THE GENERAL RULE THAT THE TWO-BLAST SIGNAL IS USED.

Crossing Vessels. Pilot Rule IX, for United States inland waters has been criticized as being inconsistent both with itself and with Articles 19, 21 and 22 of the Inland Rules. The alleged inconsistency within the rule itself lies in the fact that it begins with a clause limiting its application to cases in which *A*, having *B* on her starboard hand, has room to cross ahead of *B* without danger of collision, and follows this with a clause which requires *B* to keep clear of *A*; a requirement which is manifestly unnecessary if there is no danger of collision.

The seeming inconsistency disappears if we recognize the fact that a manœuvre which in the beginning seems perfectly safe may develop elements of danger before it is completed. The meaning of the rule is, then, that *A* may cross ahead if both ships believe that she can do so without requiring *B* to make any change of course or speed; but that, if danger of collision becomes apparent after the manœuvre has been agreed to and entered upon, *B* shall take such steps as may be necessary for keeping clear. In the situation which exists when the danger becomes apparent (after *A* has actually started to cross ahead), it is evident that *A* can do little or nothing to keep clear. Having once committed herself to the attempt to cross *B's* bow, there is nothing for her but to continue across, increasing her speed, if possible, and perhaps turning somewhat away from *B*. Whatever else is to be done now must come from *B*, who can usually make all safe by slowing, stopping, or backing, and turning to port, toward *A's* stern.

As interpreted above, Pilot Rule IX simply puts into words certain privileges and obligations which are in part implied and in part specifically set forth, in both the International and the Inland Rules; viz., the privilege of *A* to cross ahead of *B* when both ships believe that she has room to do so safely, and the obligation of *B* to keep clear if danger develops later which can only be averted by action on her part.

Viewed in this light, Pilot Rule IX is consistent not only with itself but with the International and the Inland Rules; *but it can not be held to justify the very common practice of setting aside the prescribed rules for crossing, merely as a matter of convenience.*

Except in the case already considered, where *A* and *B* believe that there is room for *A* to cross ahead without requiring *B* to change her course or speed, and the other case, to be hereafter considered, in which *A* is *obliged* to cross ahead for safety, *the*

law requires that A shall keep clear and that she shall, if possible, avoid crossing ahead; and that B shall keep her course and speed.

NOTE 49.—At this writing (1910) there is some reason to anticipate that Pilot Rule IX will be modified or annulled. This will not materially change the duties of crossing vessels as they have been defined above. *A* will still have the right to pass ahead if she has room to do so without danger of collision. *B* will still be under obligation to act for the avoidance of collision when danger appears and when *A* alone can not avoid it.

The real objection to Rule IX is not that it is inconsistent with other rules, but that it emphasizes somewhat unduly the privilege of *A* to cross ahead *under certain exceptional circumstances,* and thereby appears to place this privilege upon an equal footing with the obligation to pass astern under all ordinary circumstances.

The law in this matter is clearly laid down in the following decisions of the United States courts:

(1) "A steamer bound to keep out of the way of another steamer by going to the right, has no right, when under no stress of circumstances, but merely for her own convenience, to give the other steamer a signal of two whistles, importing that she will go to the left, unless she can do so safely by her own navigation, without aid from the other, and without requiring the other steamer to change her course or her speed. Otherwise she would be imposing upon the latter steamer more or less of the burden and the duty of keeping out of the way, which by statute is imposed on herself. When two blasts are given under such circumstances, the steamer bound to keep out of the way thereby in effect says to the other: 'I can keep out of your way by going ahead of you to the left, and will do so if you do nothing to thwart me; do you assent?' A reply of two whistles, in itself, means nothing more than an assent to this course, at the risk of the vessel proposing it. Such a reply does not of itself change or modify the statutory obligation of the former to keep out of the way as before, nor does it guaranty the success of the means she has adopted to do so." "THE CITY OF HARTFORD," Federal Reporter 23, page 650.

(2) "But from the moment that such an attempt [the attempt to cross ahead] apparently involves risk of collision, both steamers are equally bound to do all they can to avoid a collision. But this general obligation applies equally whether the previous signals were of two whistles or of one. The precise acts which either is bound to do when immediate danger of collision arises must depend upon the particular circumstances, and of these circumstances the previous understanding as to the course or intention of each vessel is one of the most important. But where the circumstances are such that a course proposed by a signal of two whistles would, if assented to and adopted, require at once, as in this case, immediate and strong measures to avoid a collision, there can be no question that such a proposal is wholly un-

justifiable, and a gross fault, when proposed by a steamer that is bound to keep out of the way, and is under no constraint of circumstances, but free to pursue other safe methods of doing so." The NEREUS. Federal Reporter, No. 23, page 455.

(3) "The rule of the Supervising Inspectors governing navigation in New York harbor, that a steam-vessel approaching another on a crossing course so as to endanger collision shall signify by a blast, or blasts, of the whistle what course she proposes to take can not be held to deprive the vessel which is on the starboard side of the other of her right to keep on her course as provided by Revised Statutes." The HAMILTON vs. THE JOHN KING. Federal Reporter, No. 49, page 469.

The remarks which precede with regard to crossing deal with cases in which the vessels are not hampered by any emergency connected with the original situation. There is another and very important case which frequently arises in crowded waters, where *A,* having *B* on her starboard hand and rather close aboard, *is obliged to cross ahead* because she has not room to manœuvre otherwise. This is distinctly an emergency situation and is covered in the International Rules by the second paragraph of Article 21, and in both the International and the Inland Rules by Articles 27 and 29. In this case the vessels exchange a two-blast signal and *A* crosses ahead, *B* taking such steps as may be necessary to let her cross safely.

Meeting Vessels. In crowded waters, it is often impracticable for meeting vessels to pass each other port to port. In such cases the practice is to exchange a two-blast signal and pass starboard to starboard. This deviation from the law is justifiable only in cases of actual necessity; yet it constantly occurs in the inland waters of the United States in cases where no possible excuse for it exists. The custom seems to be well established among pilots, to pass on whichever side is the more convenient; and it seems to be considered that the law has been complied with if the side selected is indicated by the appropriate signal.

So well established is this custom, that its existence can not be ignored; but there is no question that it is a direct violation of the law, except, as already noted, when it is actually dictated by considerations of safety.

Vessels Backing. An interesting and important point arises when one of two crossing vessels is going astern instead of ahead. It is the practice of seamen to consider in such cases that the rules apply *with reference to the direction of motion* of the ship, so that for the time being, the starboard side becomes the port side and the port side the starboard side. This practice has been sanctioned by several decisions of the courts, and may be regarded as fully established. In other words, we must consider the pilot of a backing vessel to be facing aft, toward the direction in which

his ship is moving. He must then keep clear of a vessel *on his right hand* as if that were his starboard side. And his whistle signals must correspond. Similarly, the vessel which is crossing him must regard the stern of the backing steamer as if it were the bow, etc.

Winding Channels. Where two vessels are approaching each other in adjoining reaches of a winding channel so that they are for the moment on crossing courses, it has been held by the courts that they are to be regarded as *meeting, not as crossing vessels.*

If they seem likely to meet at a bend, or in a narrow and difficult part of the channel, good judgment requires the one which is going against the current to slow until the other has cleared the difficult point and straightened out, after which there is no difficulty about passing.

This course, which is dictated by good seamanship, is in many rivers prescribed by local regulations.

Article 50 of the By-laws for the Thames reads as follows:

> "*Steam-vessels and steam-launches navigating against the stream above Richmond Lock shall ease and if necessary stop to allow vessels coming down with the stream to pass clear particularly when rounding points or sharp bends in the river.*"

Similar provisions are included in the local regulations for the Trent, the Danube, and many other rivers.

The following extract from a decision in a case of collision in the Danube, where two steamers met in a dangerous part of the channel, sets forth the view which would probably be taken by the courts in similar cases, even where no local regulations existed covering the situation. It must not be forgotten, however, that this decision has to do with a case which was actually covered by a local rule:

> **"An ascending ship must stop below the passage until a descending ship has cleared it whenever the ascending ship has notice that if she proceeds she will be exposed to the risk of meeting the descending ship at or near that point; and the descending vessel must stop above the passage when the ascending ship has reached such point and has actually begun to navigate the contracted passage before notice is conveyed to her that if she proceeds she will be exposed to the risk of meeting the descending ship at or near the point.**
>
> **"When the ascending ship neglects to stop below the passage, it is the duty of the descending ship to refrain from any attempt to exercise her right of precedence, when the intention of the ascending steamer to violate the regulations becomes reasonably apparent." The CLIEVEDEN vs. The DIANA. 7. Aspinall's Maritime Cases, page 489.**

With regard to ships which for any reason pass at a bend, see remarks to Chapter XIV on rounding a bend with and against the current.

§ VII.

INLAND RULES OF NATIONS OTHER THAN THE UNITED STATES.

The Inland Rules of other countries do not exist in a form which admits of convenient grouping. In most cases the rules are made locally for each port or river.

Officers having to navigate the inland waters of any country should use every effort to acquaint themselves with these local laws. In some cases they are to be found in Sailing Directions; in others they must be learned from pilots or other local authorities.

Generally speaking, it will be found that such local rules do not modify the International Rules in any important particulars. So far as they deal with the rules for vessels meeting and crossing, they frequently emphasize certain points of the International Rules; as, for example, the requirement about keeping to the right-hand side of the channel. In many cases they limit the speed which may be used within the river or harbor in question. Other matters with which they deal are the following: anchorage limits; privileges and obligations of tows; length of tows; size of rafts; lights and signals for dredges at work in the channel, and rules for passing these; special rules for vessels desiring to pass other vessels going in the same direction in a narrow channel; ferry-boats crossing the channel, or entering or leaving their slips; vessels hauling out from slips; marking of wrecks; pilotage; harbor police regulations; explosives on board vessels in the harbor; buoyage; mooring alongside docks or alongside other vessels; special rules for exceptionally narrow and dangerous parts of channel; etc.

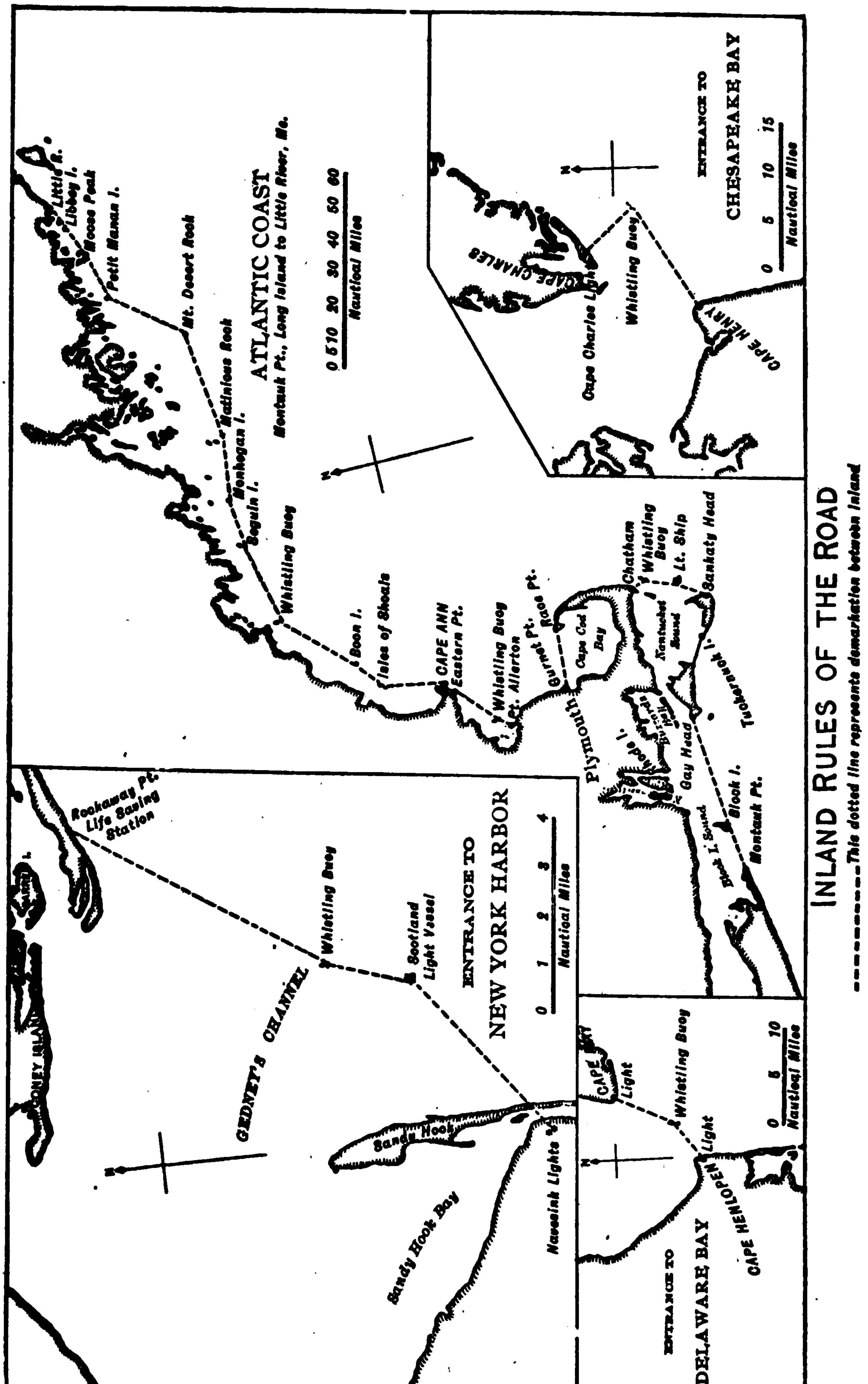
In the case of basins enclosed by breakwaters, rules are prescribed as to the conditions for entering, permission being necessary in all such cases, and arrangements being made with the harbor master.

In the case of military ports, very stringent regulations are prescribed, and vessels visiting such ports should, if possible, inform themselves of these in advance.

As a rule, all necessary information for the guidance of a stranger can be obtained from the pilot. The rules with regard to pilots and the signals for calling them are usually to be found in the Sailing Directions.

A very full and valuable collection of local rules is to be found in "Rules of the Road at Sea," by H. Stuart Moore, published by J. D. Potter, London.

Plate No. 106.


INLAND RULES OF THE ROAD
This dotted line represents demarkation between inland and International Rules
ATLANTIC COAST
Montauk Pt., Long Island to Little River, Me.
0 5 10 20 30 40 50 60
Nautical Miles
ENTRANCE TO
CHESAPEAKE BAY
0 5 10 15
Nautical Miles
CAPE CHARLES
Cape Charles Lt.
Whistling Buoy
CAPE HENRY
ENTRANCE TO
NEW YORK HARBOR
0 1 2 3 4
Nautical Miles
Rockaway Pt. Life Saving Station
Whistling Buoy
Scotland Light Vessel
GEDNEY'S CHANNEL
CONEY ISLAND
Sandy Hook
Sandy Hook Bay
Navesink Lights
ENTRANCE TO
DELAWARE BAY
0 5 10
Nautical Miles
CAPE MAY
Light
Whistling Buoy
CAPE HENLOPEN
Little R.
Libbey I.
Moose Peak
Petit Manan I.
Mt. Desert Rock
Matinicus Rock
Monhegan I.
Seguin I.
Whistling Buoy
Boon I.
Isles of Shoals
CAPE ANN
Eastern Pt.
Whistling Buoy
Pt. Allerton
Gurnet Pt.
Race Pt.
Cape Cod Bay
Plymouth
Chatham
Whistling Buoy
Lt. Ship
Sankaty Head
Nantucket Sound
Tuckernuck I.
Gay Head
Block I.
Block I. Sound
Montauk Pt.

§ VIII.

LAWS RELATING TO THE RULES OF THE ROAD.

Penalties are prescribed for the infringement of these rules, by all nations which have adopted them as laws, and these penalties do not depend upon the question whether damage has or has not resulted from the infringement.

Where damage is done, and can be shown to be the result of neglect or violation of the rules, it is held, in the absence of proof to the contrary, to be the fault of the person having charge of the deck of the vessel offending, who will be considered guilty of a misdemeanor and punishable therefor. If death ensues, he will be subject to a charge of manslaughter.

In every case of collision, it is the duty of the person in charge of each vessel, to stay by the other and to render such assistance as may be practicable, provided he can do so without damage to his own ship, passengers and crew.

He is also required to give to the master of the other ship the name of his own ship and of the port to which she belongs, and the ports to and from which she is bound.

As soon as possible after the collision, he must cause an entry to be made in the log book, of the collision and of all facts in connection with it.

§ IX.

SITUATIONS, LIGHTS, FOG-SIGNALS, ETC.

Certain typical situations arising under the Rules of the Road are illustrated in Plates **99** and **100**.

Vessels' Lights, as seen from another vessel are illustrated in Plates **101**, **102**, **103**, **104**.

Whistle Signals, as used under various conditions, are illustrated in Plate **105**.

The limits within which the United States Inland Rules apply are shown in Plate **106**.

CHAPTER XIII.

MANŒUVRING TO AVOID COLLISION.

§ I.

The difficulties and dangers with which this chapter has to deal are principally connected with darkness and with fog. In daylight and in clear weather, the avoidance of collisions should be simple enough. This chapter will therefore deal, first, with steamers meeting or crossing at night, and later, with the more difficult question of manœuvring in a fog.

As an aid in determining accurately the bearing of a light sighted at night, and of readily recognizing a change in this bearing, it is convenient to have installed, close to the bridge compass, a "pelorus" or dumb-compass, marked to degrees and to quarter points, accurately adjusted with its zero in the fore-and-aft line of the ship, and with a sighting-vane pivoted at the center.

It is well also to establish a clearly marked fore-and-aft line from a convenient point on each side of the bridge to some conspicuous point near the bow, by which the line on which the ship is heading may be picked up at a glance.

§ II.

Steamers Meeting.

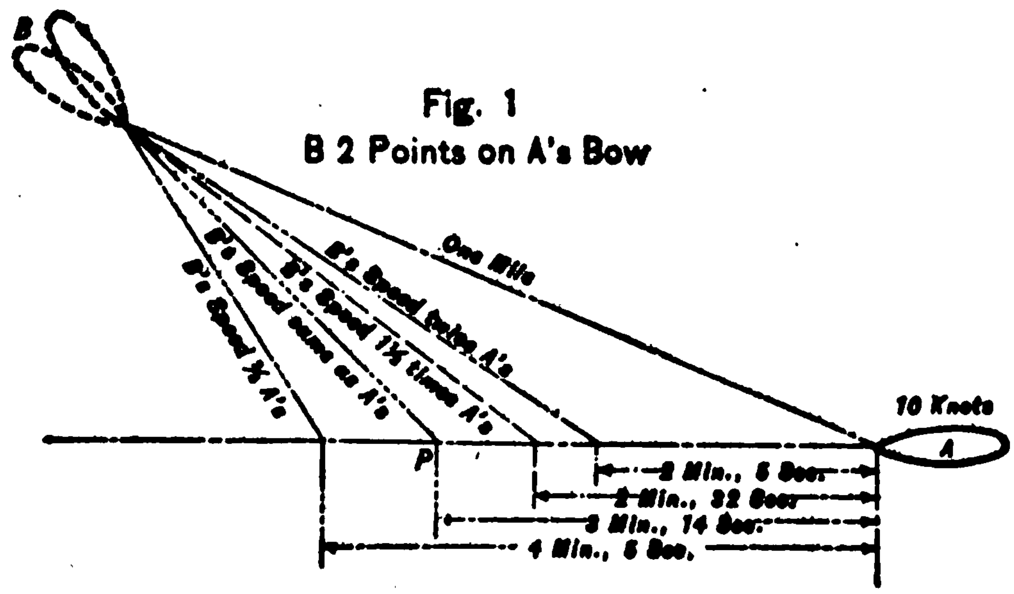
Attention has already been called to the fact that this situation is not as simple as it at first appears, for the reason that vessels which seem to be approaching each other "end-on or nearly end-on," may in fact be crossing at a considerable angle.

There is no rule which can be laid down to eliminate the danger of such misunderstanding; but there is a certain gain in recognizing the existence of the danger and the necessity for watchfulness. If the helm is to be put to port,[1] this should be done while the ships are separated by a perfectly safe distance, and the course changed to starboard sufficiently to make sure of shutting out the green light from the view of the other ship. It is of course impossible to do this in a narrow channel, nor will it be important to do it there, as each vessel will know the course that the other must be steering; but the change of course should always be made as early as the channel permits.

1. right rudder.

Fig. 1

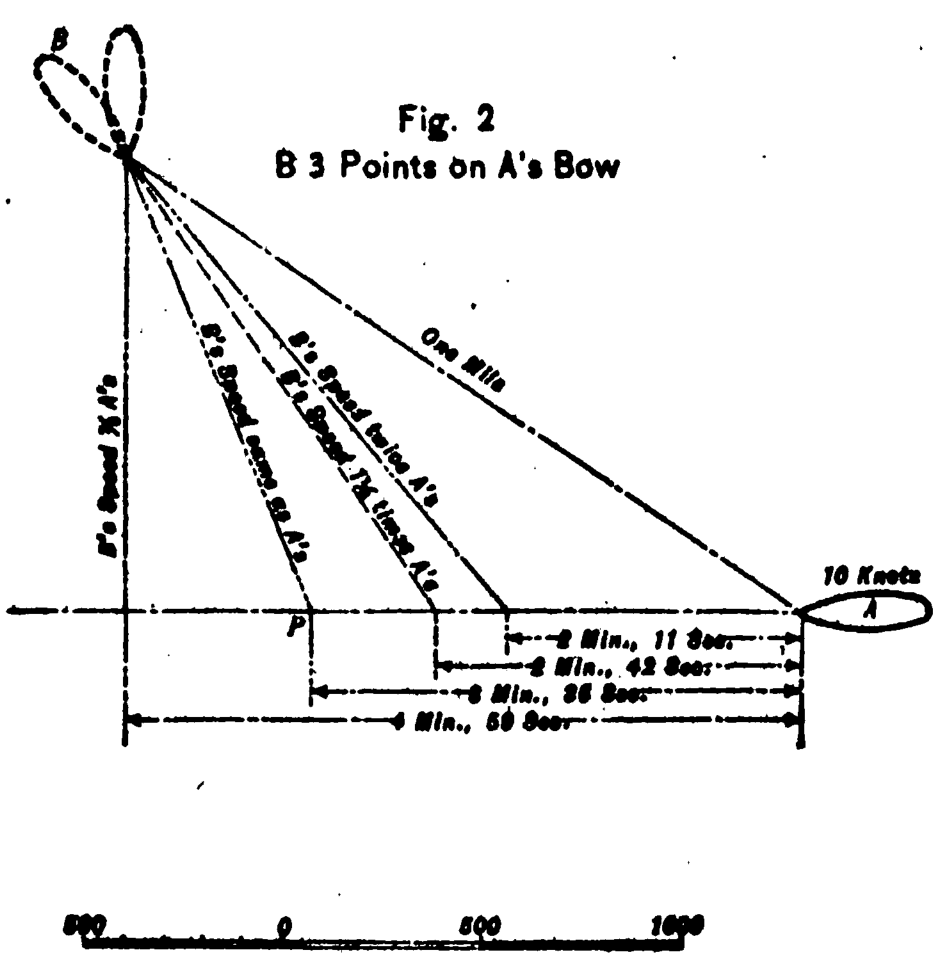
B 2 Points on A's Bow



The time intervals shown assume A's speed as 10 Knots, but can be easily corrected for any other speed.
Ships are not drawn to scale.

Fig. 2

B 3 Points on A's Bow

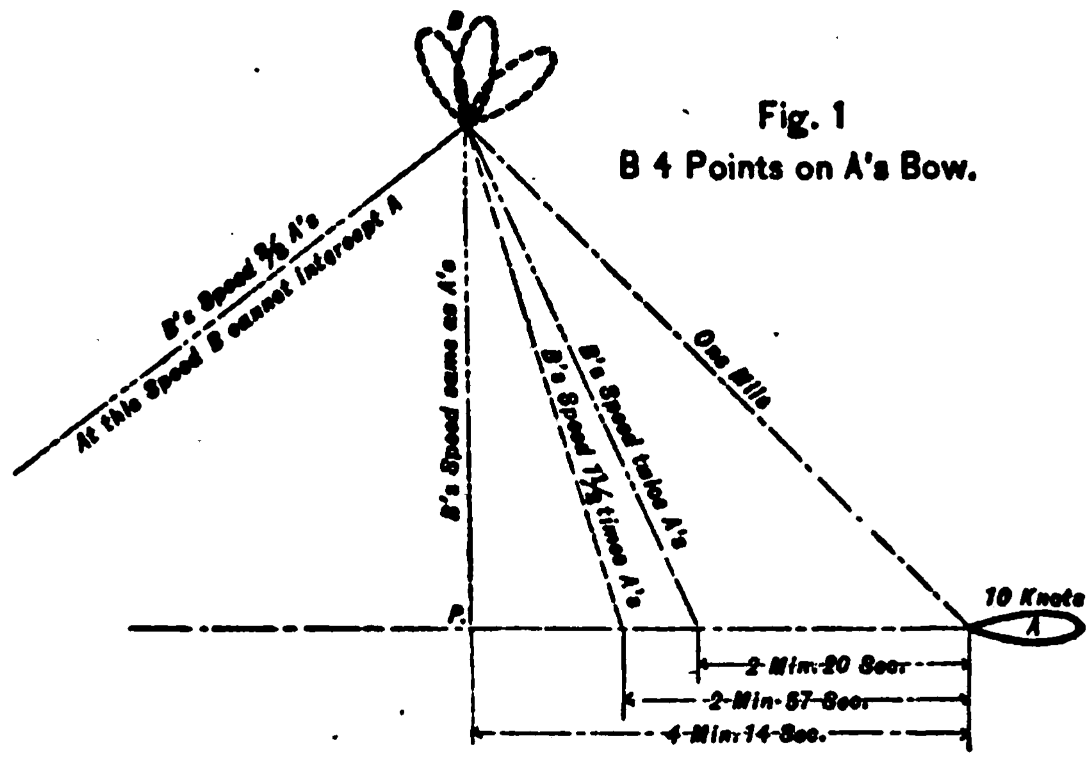


MANOEUVRING TO AVOID COLLISION.

Showing the points at which A and B will meet for various relative speeds.

Plate No. 108.

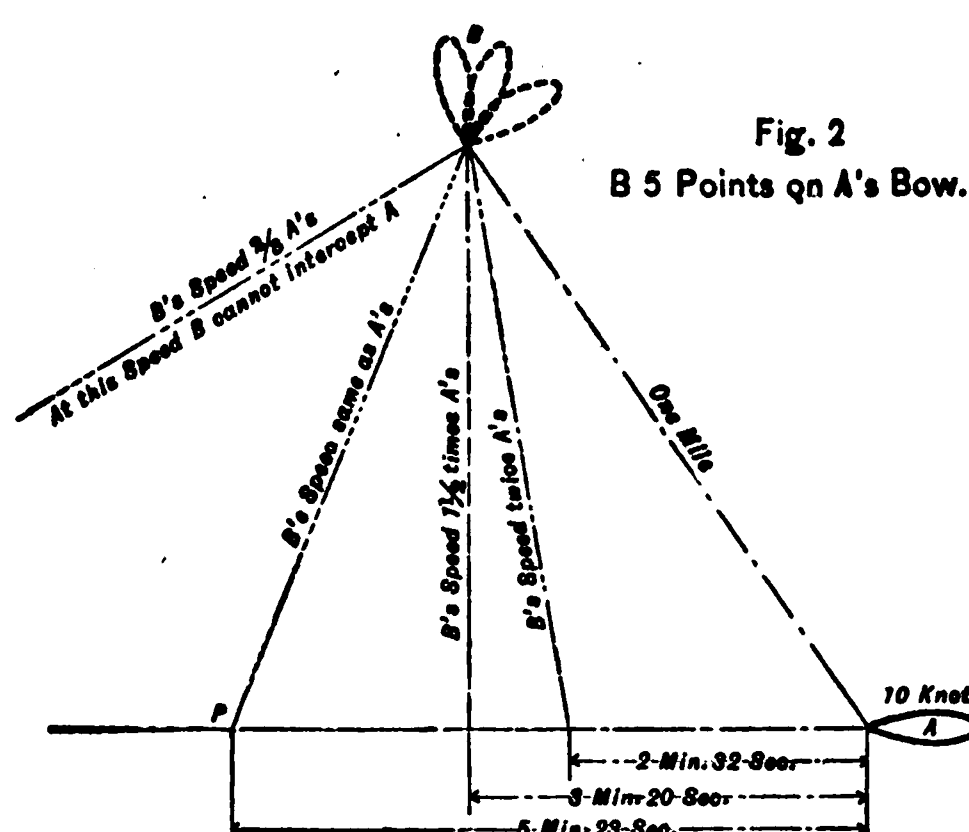
Fig. 1
B 4 Points on A's Bow.



The time intervals shown, assume A's speed as 10 knots, but can be easily corrected for any other speed.

Ships are not drawn to scale.

Fig. 2
B 5 Points on A's Bow.



Showing the points at which A and B will meet, for various relative speeds.

500 0 500 1000

Scale of Yards

MANOEUVRING TO AVOID COLLISION

When meeting another vessel in a narrow channel, there is danger in changing course too much, as to do so opens the broadside to a possible blow from the other ship. A small change made promptly, is safer than a greater change made after the ships are close aboard. On the other hand, there is the danger already pointed out, that, at night, a small change of course will not be seen by the other ship. In this situation, range-lights are especially valuable, as giving instant notice of the slightest change in the heading of a vessel seen end-on or nearly so.

In navigating crowded channels, pilots try to avoid changing course; preferring, whenever it can be done with safety, to keep clear of other vessels by reducing or increasing speed. This is less confusing than changes of course where several vessels are trying to keep clear of each other.

§ III.

STEAMERS CROSSING.

Note.—In this section, the steamer having the other on her own starboard hand is called A; *the other* B.

As preliminary to a detailed discussion of cases arising under this heading, attention is directed to the figures of Plates **107** and **108**, in which the vessels are assumed to be separated by one mile, and the courses plotted which B must be steering, for various rates of speed, in order that there shall be danger of a bow-to-bow collision with A.[1]

We do not attempt here to draw any conclusions which involve a knowledge on the part of either vessel, of the course or speed of the other.

It is apparent from these figures that, if there is to be a collision, the point at which it will take place depends upon the relative speed of the two ships. If the speeds are equal, it will be at P, equidistant from A and B. If B has the greater speed, the point of meeting is crowded back towards A, and the space available for A to manœuvre is reduced. If, on the other hand, B's speed is less than A's, the point of intersection recedes, and the space at A's command is correspondingly increased. It follows from this that if A is running at a low speed and finds another vessel closing in on her without change of bearing, she will know that the space at her command for manœuvring is comparatively limited, as, in all probability, the point of intersection of the courses is not far ahead.

[1] We cannot, of course, disregard the length of the ships; but as a basis of argument we deal here with the bows only. The figures will make it clear in what way the argument must be modified to include the meeting of the bow of one ship with the stern of the other.

As regards B, if it happens that she is running at very high speed, she, too, will know that in all probability the courses intersect near A and that A has probably but little space for clearing her (B's) line. It may therefore be urged that, so far as B is concerned, the obligation upon her to act for the avoidance of collision, under Art. 21 of the Rules of the Road, will increase with her speed; that is to say, if her speed is so high that A's is not likely to equal it, she will know that her course is *probably* crossing A's at a point which leaves A but little space in which to manœuvre for mutual safety.

As regards the *time* available in the cases illustrated in Plates 107 and 108, we cannot discuss this without assuming a definite speed for A. In the figures, this is taken at 10 knots, so that B's speed becomes, for the courses laid down, 10, 15, 20 and 7 knots.

If A's speed is greater or less than 10 knots, the intervals must be changed correspondingly.

If we take the distance between the ships as greater or less than one mile, the scale of the figures must be changed.

With these speeds, we see that, when B is distant one mile and crossing without change of bearing, the bows of the two ships will meet after the intervals shown in the figures.

An important point brought out by the figures is that, if B's speed is materially less than A's, there are only certain bearings on which B can threaten collision. Suppose, for example, that B's speed is two-thirds of A's, and that she bears four points on A's bow. She cannot by any possibility reach the line of A's course in time to intercept and collide with her. As the difference in speed increases, this point comes out more and more strikingly. If A's speed is three times B's, there can be no collision if B is sighted more than 1¼ points on the bow.

It follows from this, that in the case of a steamer running at a speed so high that no vessel which is likely to cross her course can be expected to have anything like an equal speed, the danger sector is confined to a few points on either bow.

Take the case of an ocean liner, running at a speed of 20 knots, and consider her relation, for example, to sailing-vessels crossing her route. These vessels will not have more than one-third to one-half her speed. To threaten collision, then, they must bear a very little on the bow, and can be cleared, in most cases,

with a few spokes of the helm.[1] Although this point is not usually specifically brought out, it is probably somewhat vaguely held as the basis of the contention so strongly insisted upon by the officers of the great liners, that it is safer for them to run at full speed in a fog than to slow down. This subject will be discussed in a later section, in connection with "Fog," and it will be shown that this is only one of many points to be considered in thick weather, and that the unquestionable advantage of high speed from this point of view is much more than counterbalanced by other considerations.

§ IV.

A large proportion of steamers meeting at sea approach each other on bearings from ahead to four points on the bow. It happens that this is, for reasons which will appear hereafter, the most dangerous bearing on which they can approach; and it results from this coincidence of the maximum frequency of occurrence with the maximum of danger, that something like seventy-five per cent of all collisions reported, are between vessels approaching each other on these bearings.

It will be convenient to distinguish two general classes of situations: *1st*, Those arising under ordinary conditions, where vessels sight each other at normal distances and have plenty of time and space for manœuvring to avoid collision; and *2nd*, Those in which they do not see each other until dangerously close. If any doubt exists as to whether they are dangerously close or not, it should of course be assumed that they are.

1st. Masthead lights are required by law to be visible five miles, on a clear, dark night; and this law is fairly well complied with. We shall certainly not be in error if we assume that they will show four miles, and that the side-lights of a steamer will show half as far. If bearings are taken from the time the masthead lights are seen, the situation should be perfectly clear by the time the side-lights are made out, and if danger of collision has been found to exist, A (the "giving way" ship) should be ready to act at once. She may give way by changing speed, or course, or both, but it is always simpler to change the course than to reduce the speed materially; and this has the further advantage that it gives notice to B of what has been done—provided the course can be changed sufficiently to open the red light. It will not usually be *necessary* to make so great a change

1. wheel.

as this, merely to insure passing astern, but it is very desirable to do it if B is not too far on the bow, as it immediately clears up the situation for both ships. The whistle signal required by the new Rules of the Road, for a change of course, is an additional safeguard in this case, which could not be used for a mere reduction of speed. If, however, B is more than three or four points on the bow, it will suffice to slow as much as may be necessary to let her draw ahead, changing course later if it shall seem advisable.

In changing course to avoid collision, port helm[1] is required of A by the article which directs her, whenever possible, to pass astern of B. This is a survival of the old "Law of Port Helm" which has been the object of such violent denunciation from writers on the Rules of the Road. When confined, as it is by the present rules, to the ship having the other on her own starboard hand, this law is perfectly sound; but it was at one time regarded as applying to all ships under almost all circumstances.

2nd, If the vessels are dangerously close when they sight each other, A is relieved from the obligation to pass astern of B, unless it shall appear that this is the safest course that she can take. We shall find that, as a matter of fact, it is in a majority of cases the only course that can give her a hope of safety; and that port helm[1] is usually even more imperatively demanded of her in this case, than when the space available for manœuvring is greater.

The first impulse of many officers in such a situation is to turn away from the danger, and at the same time to reverse the engines with full power. This course is much more likely to cause collisions than to prevent them. It may be right for B (the holding-on vessel) to turn away, if the emergency is such as to call for any action on her part; but if she does this, so far from reversing her engines, she should, if possible, increase her speed, as her whole effort must be directed to getting across the bow of A as quickly as possible. On the other hand, A should reduce her speed, but should at the same time turn to starboard.

A vessel turning away from another vessel to avoid collision should always continue at full speed, as the effort involved in this course is an attempt to cross the other vessel's bow. To turn away and slow is the surest possible way of bringing about collision.

To make it clear why A turns toward the danger instead of away from it, we may refer to Plates **109** and **110**, where B is placed, in the successive figures, on bearings from two to five points on

1. right rudder.

Plate No. 109.

Fig. 1

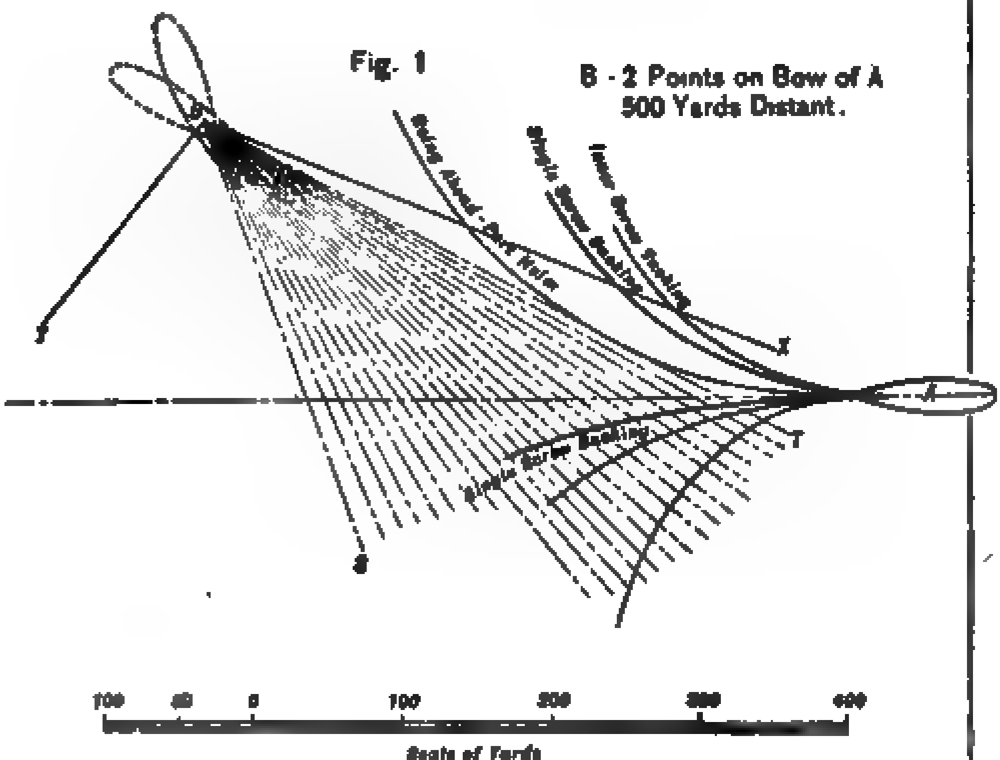
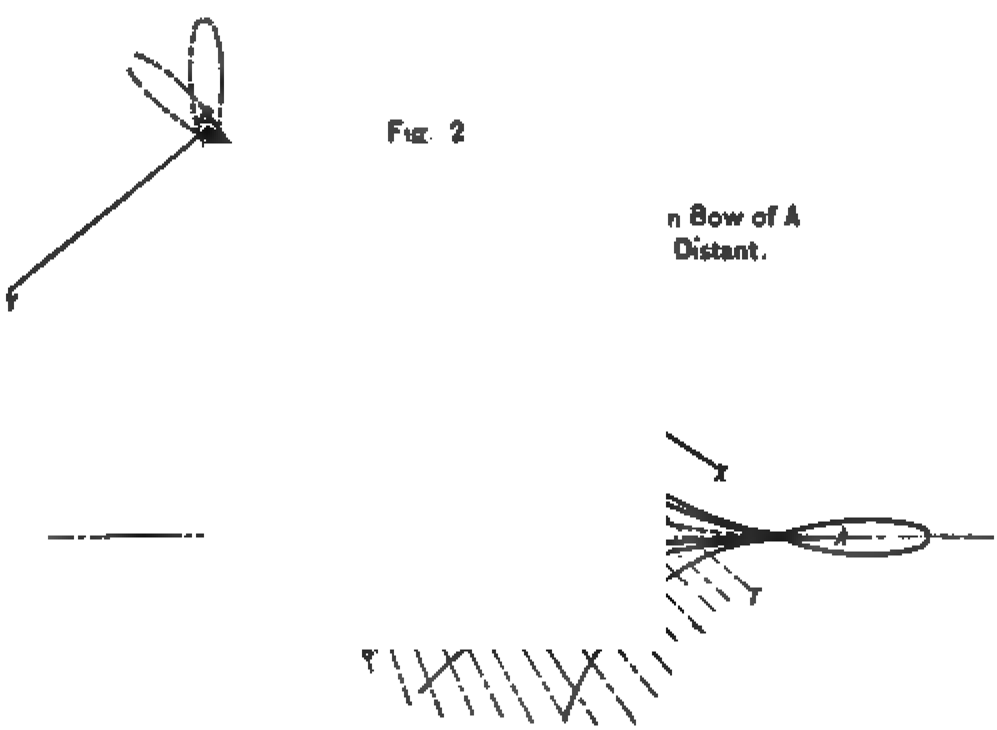
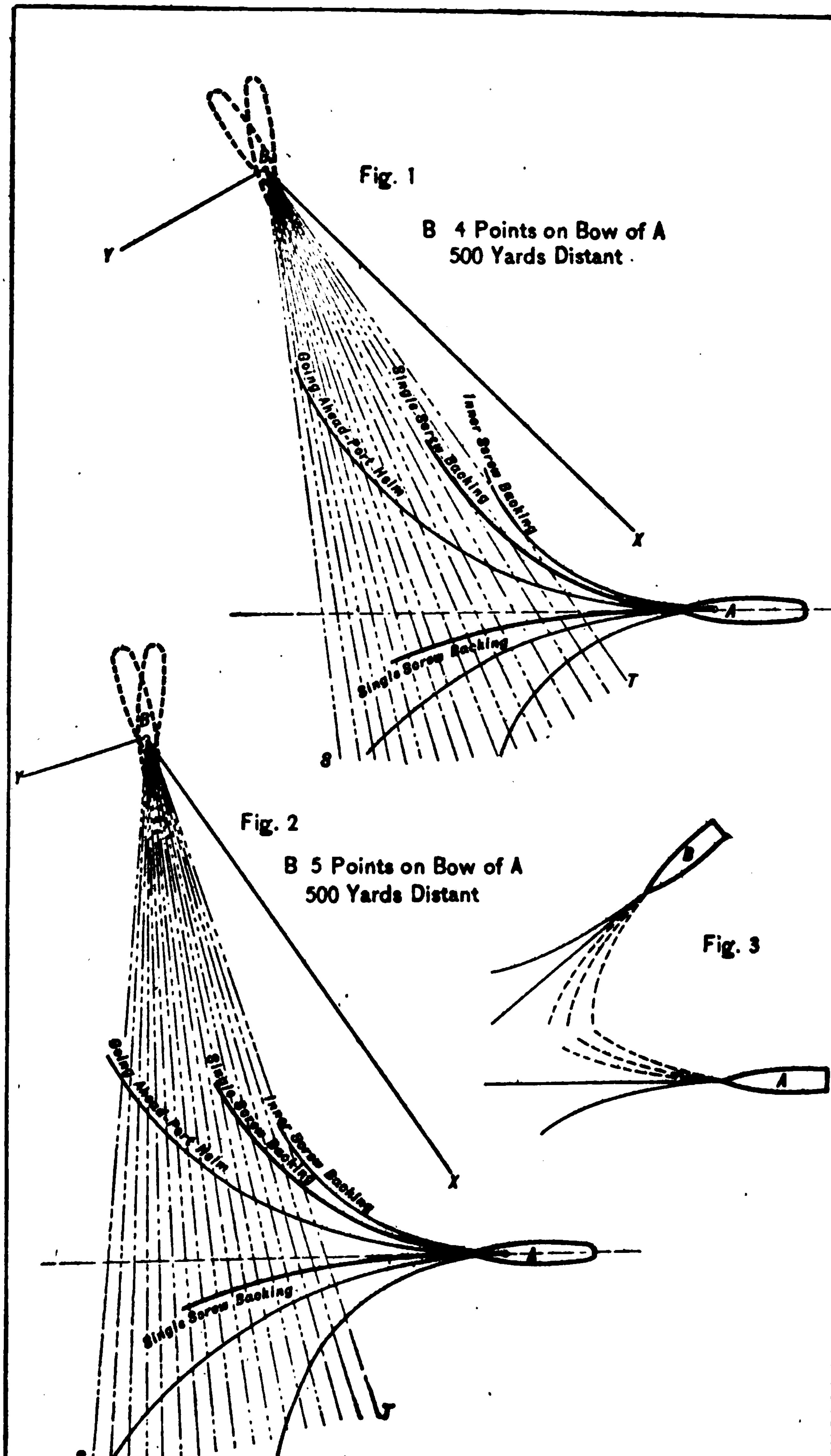


Fig. 2



MANOEUVRING TO AVOID COLLISION.

Plate No. 110.



MANOEUVRING TO AVOID COLLISION.

A's bow, and showing a red light. In such a situation, the action to be taken will not depend upon the exact distance between the ships. This distance is here taken, for convenience of plotting, at 500 yards, but it may be more or less than this without modifying the principle involved, except in one special case to be hereafter considered.

As we cannot suppose that A in this case has time to watch for a change of bearing, or that she will have any information of B's course and speed beyond that given by a red and white light, we must consider that, so far as A's knowledge goes, B may be heading anywhere between the lines BX and BY. If, however, she is heading nearly along BX, she is safe to pass astern of A;[1] and if she is heading well off toward BY, the danger of collision, although it may still exist, will be comparatively remote. The situation will not be one of serious emergency unless B is heading on some course within the sector SBT.

If A turns to starboard and reverses, using helm and engines together to the best advantage, she will follow the heavy line (approximately). If she has twin screws and reverses the inner one, at the same time putting her helm aport, she will follow the light line. In either case, if she does not turn clear of the danger sector, she will cut only a few of its lines (that is to say, only a few of the possible courses of B); and she will at the same time present her stem to B, thus reducing, at once, the danger of collision and the damage to be expected if collision occurs. If she turns to port, she not only cuts every one of the courses of B within the danger sector, but she throws herself across B's path broadside on, inviting the most fatal blow that one ship can give another.

If it be contended that, in placing the ships 500 yards apart, we have taken too great a distance for urgent danger, the answer is that at less than this we approach the case in which collision is not only imminent but almost inevitable and for which no hard and fast rules can be laid down. Whether, in such a case, it is safer to turn toward the danger or away from it will depend largely upon the angle at which the courses con-

[1] It will be noted that A could, by turning with the starboard screw backing, collide with B even if B is heading along BX; but long before this could happen, A would see B's green light and would resume her course.

verge, and when the vessels are very close together, we may assume that something will be known about this, since it is hardly to be supposed that two vessels within a few hundred yards of each other will not see something besides each others running lights. If it is seen that the courses converge as in Fig. 3, Plate **110**, the ships being very close together, it is clear that each should turn away from the other, and stop. If *A* has twin-screws she would back the port screw full speed. If she has a single right-handed screw, it may be dangerous to back if *B* is very close.

In the case where A has B nearly on the beam, the importance of turning inward is less marked than when she is on the bow, and it is generally safe to slow or stop to let her draw ahead, or at least to let the situation declare itself clearly.

With regard to B's course when she finds herself called upon under Art. 21 to act for the avoidance of collision with a vessel on her port hand (A), she should, in most cases, turn away, with port helm, and keep her speed or if possible increase it. But this involves presenting her broadside to A; and if the ships are so close that it is evident collision cannot be avoided, there is no question that B should turn inward, presenting her bow as nearly as possible to A, and stopping; remembering, if she has a single (right-handed) screw, that backing will throw her head to starboard and may defeat the object of the manœuvre. This is a situation for which it is impossible to lay down hard and fast rules; and all that is attempted here is to call attention to all the factors in the problem.

If B has twin screws, she should, if she puts her helm to starboard,[2] reverse the inner (port) screw, and follow this up by reversing the other one as soon as she has begun to swing. There is a chance that the ships may still avoid each other, and if they meet, the damage will be less than if either of them strikes the other full on the broadside.

If A (a steamer) meets a sailing-vessel, her obligation to keep clear is the same whether the latter is on her starboard or her port hand. The law requires her, also, whenever the circumstances admit, to give way by passing astern. Where a right-handed screw steamer is to turn to port to avoid collision with a vessel approaching from that side, it is important to remember that if the engines are reversed they will probably destroy the effect of the helm, and throw the head to starboard, thus increasing,

2. left rudder.

rather than diminishing, the danger. The point is of special importance because this situation, if arising at all, is likely to come in the form of an emergency, as the lights of sailing-vessels rarely show at the distance prescribed by law, and frequently cannot be seen until close aboard. With twin-screws it is as easy to turn to one side as to the other.

It will be clear from what has been said in § II, concerning the relation of a fast steamer to a comparatively slow vessel crossing her track, that there is here a strong temptation to turn away from the slower vessel in the hope of getting across her bow; and no doubt there are situations in which this is the only thing to be done; but it is accompanied by serious risk and should be resorted to only in an extreme emergency. If it is attempted, *the speed must be maintained at its maximum.* In the event of turning inward, the rules laid down in § IV of Chapter XI should be carefully observed; that is to say, in turning to port (for example) the helm should be put hard a-starboard[2] instantly and the engines stopped; then, *after the head has begun to swing decidedly to port,* the engines should be reversed, and, finally, the helm shifted to hard aport. This supposes a right-handed screw.

§ V.

IN A FOG.

An officer hearing the fog-signal of a vessel which he cannot see, can usually form a general idea of its bearing and may be able to judge something of its distance; but even with regard to these points, there is danger of serious error, and of all other points he is absolutely ignorant. The other vessel may be heading toward him, or crossing his course at any angle, or running parallel with him. If, however, he hears her signal more than once, he can judge whether she is drawing nearer or not, and can perhaps tell something of her course; and if she is stopped, her signal will tell him this.

A steamer's whistle can be heard, under favorable circumstances, two miles or more, and rather farther in a fog than in clear weather; but so many things affect the question of audibility that it is not safe to rely upon hearing it more than, say, half a mile, even when all conditions seem to be favorable. The fog-horn of a sailing-vessel can in some cases be heard a mile or more, but in other cases not more than a few hundred yards. The law does not require the signal (of a steamer) to be sounded oftener than

2. left rudder.

once in two minutes, and in this interval, a vessel running 10 knots will cover between 600 and 700 yards, while two vessels approaching each other on a bow bearing will draw together by half a mile.

It can be shown that the safest bearing on which one vessel, A, can have the fog-signal of another vessel, B, is directly ahead. If the signal indicates that B is stopped, she can be easily avoided; and if she is standing across, she will be clear before A can reach her. There is no danger of collision, unless she is heading toward A; that is to say, within the very small angle subtended by A's beam; and in this case the vessels should be able to pass clear, with port helm, after sighting each other. If they meet, it will be either stem to stem or with a glancing blow, and such collisions are never very serious.

Not only is a blow on the broadside far more dangerous than one on the stem, but the length offered by the broadside to possible collision is from eight to ten times as great as in the case of the stem; from which we may argue that, so far as other considerations of law and seamanship permit, any vessel in danger of collision with another should present her stem to the danger, rather than her broadside.

The rules governing the manœuvring of steamers, as laid down in Chapter XI, are evidently of maximum importance in a fog, as are also the facts in connection with stopping, given in Section VI of this chapter.

Broadly speaking, the Rules of the Road for vessels crossing apply in a fog as well as in clear weather, but a certain time must elapse, after the signals are first heard, before it can be determined whether the vessels are in fact crossing, or passing clear of each other. If they are passing clear, any change of course on the part of either may introduce danger; and no such change will be justifiable unless it can be shown to contribute, on the whole, to the *probability* of safety. In the interval of uncertainty following the first hearing of the signal (forward of the beam), the law requires that both vessels shall stop their engines. It does not require them to reverse, because this would destroy, to a great extent, the control of the ship by the helm.

Starting with this single demand of the law, we have to inquire whether anything else is demanded by seamanship.

F
In
A hears
to S

MANOEUVRING TO AVOID COLLISION

Consider, first, the case of a steamer hearing, *on her starboard bow*, the signal of another steamer, of whose exact bearing she cannot be sure, and of whose distance she knows only that it is not great. A, Plate 111.

A has no means of knowing whether the vessels are crossing or not, but she knows immediately that, if they are crossing, she must keep out of the way. If she contents herself with stopping her engines, she will range ahead, with constantly diminishing speed, along the line AK. If she turns to either side, she will follow one of the curving tracks.[1] As regards the possible courses of B, we need consider only those which involve a chance of collision. These will all lie within the "danger sector" shown. Clearly, if A turns inward, she cuts comparatively few of these possible courses of B, and at the same time she presents her stem, instead of her broadside, to such danger as may exist. If time and space permit her to turn fully toward B, she will have placed herself in the safest position she could take with reference to another vessel whose course is unknown.

If, on the other hand, A keeps her course or turns away from B, she cuts directly through the danger sector, and exposes her broadside to collision in case it proves that B is heading across.

From the moment when it becomes clear that B is crossing, the Rules of the Road apply to the situation; and these rules require that A shall keep clear and that she shall, if possible, pass astern of B, to do which she must turn inward; that is to say, the manœuvre required of A, *after the ships have drawn dangerously close*, is the same that is suggested by the foregoing considerations for the very beginning, when the time and space available for it are much greater, and while the ship has speed enough to be under satisfactory command.

In view of all these facts, it seems safe to say that a steamer in a fog, hearing the signal of another vessel *on her starboard bow*, should turn toward the signal in the shortest possible space and time, stopping her engines as required by law, and backing if this will assist in turning. She should not continue backing long enough to come to a dead stop unless it is evident that this is called for by the emergency. In other words, it is not well to renounce control by the helm while doubt still exists about the course and position of the other vessel. Having brought the

[1] The tracks shown are for a vessel 300 feet long, but the conclusions drawn from them will hold for vessels of any length.

signal ahead, she should hold the compass course thus fixed until it becomes clear what course the other vessel is making.

If the signal heard is on the starboard hand, but only a little forward of the beam, the advantages of turning immediately toward it are not so marked, although there is high authority for recommending it even in this case. It is probably better for A, after stopping her engines, to hold her course for awhile, bearing in mind, however, that if she finds reason to change her course at all it will be to starboard, and that she should be ready to do this the moment it becomes clear that B is crossing. If, later, she turns to starboard, she will probably have reason to back her engines at the same time.

We have now to consider what B should do upon hearing the signal of A, a steamer, on the *port* hand. Certain of the arguments which have been applied to the preceding case apply with equal force here, and, as far as they go, suggest that B also should turn inward (toward A); but a decisive argument against this is that, if the ships are not crossing, B is not called upon to take any action whatever; and if they are crossing, it is her duty to keep her course, letting A pass astern of her, and directing all her own efforts to getting across A's bow as quickly as possible. She should, therefore, in the period of uncertainty following the first hearing of the signal, hold her course with her engines stopped. The moment that the situation is recognized as one of crossing, she should start her engines ahead, *unless the circumstances make it evident that she cannot get across.* In this case, which can only arise when the ships are very close, she should turn toward A and stop. Whether she should back or not will depend upon the effect this will have on her steering, and upon other circumstances as they reveal themselves at the moment.

An officer on the bridge of a steamer, hearing a sailing-vessel's fog-horn forward of the beam on either side, has several things to help him in deciding whether danger exists and how it can be avoided. The number of blasts heard will tell him on which tack the other vessel is, and the force and true direction of the wind will tell him much about her course and speed. The law requires him to stop his engines, in this as in other cases; and if the vessels seem to be meeting or crossing with danger of collision, it requires him to keep clear, and, if circumstances admit, to avoid

crossing the other vessel's bow. As a fog-horn can be heard but a very short distance, it must generally be assumed in this situation that the vessels are dangerously close; and to decide whether "circumstances will admit" of passing astern of the sailing-vessel, calls for rather nice judgment; the more so as the decision must be formed without the least delay. If the steamer is running as slowly as under the law she should be, and with the large reserve of power which, as we have seen, will enable her to stop within her own length, or slightly more than this, she should usually turn toward the signal and reverse her engines (provided danger of collision is found to exist). If no danger exists, the steamer keeps course and resumes speed.

An officer in charge of the deck of a steamer should at all times, but especially at night and in a fog, have as exact a knowledge as possible of the true direction of the wind. This can be told accurately enough from the surface ripples on the water, when these can be seen. At other times, it must be estimated from the apparent direction and force of the wind and from the general direction of the sea, remembering, however, that this does not always run with the wind blowing at the time.

The wind is rarely fresh in a fog, but may blow with any force in falling snow or heavy rainstorm, either one of which is more to be dreaded than a fog.

Exception may be taken to the rules laid down above, on the ground that by turning immediately toward a fog-signal, we run a risk of introducing danger where none would otherwise exist. It should be noted, however, that this action is recommended only for the vessel which, in case there proves to be danger, must keep clear, and *and keep clear by this very manoeuvre;* also, that a vessel turning and backing at the same time, gains very little ground to the right or left of her original course, and finally that, as already noted, the best we can hope to do in a fog is to take the course which gives the greatest *probability* of safety *in view of the evidence available.*

§ VI.

SPEED IN A FOG.

This subject has been treated as a matter of Law, in connection with the Rules of the Road. It will be treated here as a matter of Seamanship.

It has been shown in § III, that a vessel running at very high speed, can, with comparative ease, avoid collision with a slow vessel crossing her path, provided that she makes out this vessel at a fair distance and is sure that it is crossing.

But in a fog, while a signal may be heard at a considerable distance, it can never be located with precision, and there is no means of telling whether the vessel from which it comes is crossing or not. The advantages of high speed are confined to cases in which the crossing vessel is actually seen; and in a fog, a vessel seen is usually so close aboard that a steamer running at full speed would strike her before helm or engines could be touched.

The claim usually put forward by the defenders of high speed is that a steamer handles better at high than at low speed. This is true enough as regards *time*, but altogether false as regards *space*;[1] and in avoiding collision, space, and not time, is the controlling factor. Time enters into the question, it is true, but in another way than this, and a way that is all in favor of low speed. *The great hope of safety in a fog lies in the sound signals prescribed by law.* These are required to be sounded once in two minutes. But in two minutes, a vessel running fifteen knots will pass over half a mile, while two vessels approaching each other, will draw together by a mile.

As there are many conditions of the atmosphere in which signals cannot be heard a mile, it might easily happen that two vessels running at this speed would find themselves in collision without either one having heard the signal of the other. Moreover, a signal once heard gives very little information. It tells of danger, and is a command to stop the engines; but it can rarely be located, even as to the side from which it comes, until it has been repeated once or twice; and even after it is located approximately, there is certain to be some delay in acting.

At five knots, the time available for repetition of the signals, for comprehension of the situation, for decision as to the course called for, and for action upon this decision, is three times as great as at fifteen knots; and it seems hardly necessary to insist that in such an increase of time, there is an enormous increase of safety.

Closely connected with the question of speed in a fog, is that

[1] See Chapter XI, § II, where it is shown that the space in which a vessel turns does not greatly vary with her speed.

of the space in which a steamer can be stopped under various conditions. This space will depend upon the proportion of her available power which is in use for going ahead. If she is using full power, so that she has no reserve available for backing, it is found that she can be stopped in from three to five times her length; that is to say, the space required is independent of her speed, and directly proportional to her length. Thus a vessel two hundred feet long can be stopped in nine hundred feet, while one six hundred feet long may require nearly three thousand feet.

But a vessel in a fog, running at reduced speed, can have, and should have, a large reserve of power ready for instant use in backing, the only limitation upon this being that "blowing off" shall not be necessary. The greater the proportion which this reserve bears to the power in use for going ahead, the shorter will be the space in which she can be stopped by bringing the reserve into play; and it is evident that, at low speed, a much larger percentage of power can be held in reserve without blowing off, than would be possible at high speed. With such a reserve ready for immediate use, a steamer should be able to stop in two lengths or less; and if she turns while stopping, this distance is still further reduced.

Since both the space in which a ship will stop and that in which she will turn are directly proportional to her length, the importance of running slow and with a large reserve of power is greater in the case of a large steamer than of a small one; yet the largest steamers afloat are the very ones which habitually and openly set the law in this matter at defiance.

A reason frequently given for advocating high speed in a fog is that, the fog belt being of definite width, the danger of collision will be reduced by getting across it as quickly as possible. This is like saying that if one is called upon on a dark night to cross a public square in which people are moving about in all sorts of directions, it will be safer to run across at full speed than to walk slowly. It can easily be shown that in neither of these cases is the probability of collision reduced by reducing the time in which the danger space is crossed.

It is surprising that in none of the discussions which come up from time to time upon the subject of fog-signals, is any sugges-

tion made as to the use of the voice. A good voice can be heard without difficulty a quarter of a mile, and by the use of a megaphone this distance can be more than doubled. It would seem that advantage might often be taken of this fact to establish communication through a fog, and to exchange information as to courses steered, speed, etc.

One of the greatest difficulties in deciding upon a course of action in a fog comes from the impossibility of determining with certainty the direction of sounds. This necessarily reduces the value of all rules which involve the location of signals heard.

There is on the market an instrument designed to overcome this difficulty. Should it prove a success, its value could hardly be overestimated.

It is well known that fogs do not usually extend to any great height, and that they are often thin at, and for some distance above, the surface of the water. They are probably denser at about the height of a steamer's bridge than at any other point. By stationing lookouts as high and as low as possible, dangers may sometimes be made out above or below the fog, long before they can be seen from the deck or the bridge.

It is important to remember that when vessels sight each other through a fog, the signals of Art. 28 of the Rules of the Road become available and must be used if the course is changed or the engines backed. These signals must not be used when the vessels are not in sight of each other, no matter how close they may be.

In the event of collision, it is a natural impulse for the vessel which has rammed the other, to back out as quickly as possible. This is often the worst thing that could be done, since her bow must be for the moment closing more or less perfectly the hole that it has made. Often, by keeping the engines of the ramming ship at dead slow ahead, it will be possible to save the other ship from filling and sinking long enough for the passengers and

crew to make their escape—perhaps directly to the deck of the ramming ship.

As to the duties of both ships under the law, see § VIII of Chapter XII.

Collision mats, supplied to all men-of-war, are rectangular mats made of two or more thicknesses of canvas, quilted together, and fitted with lines from the corners, for getting the mat into position over the side wherever it may be needed, and holding it there. This calls for "*hogging lines*," leading from the lower corners under the keel and up on the opposite side, and others leading up to the rail on the side where the mat is placed; also for "distance lines" from the corners to stretch the mat forward and aft. To get the hogging lines under the keel, they must be dipped over the stem and passed aft to the point where they are needed. It was at one time the custom in the navy to carry hogging lines under the keel at all times, but this was found to chafe the lines and to rub off the paint. It is now prohibited.

Hogging and distance lines are usually of chain or wire or both, and are always galvanized.

A collision mat properly placed may be a great nelp to a ship which is dead in the water, but its usefulness is greatly reduced if she attempts to steam at any speed. Its principal value is to make other repairs possible—usually from the inside of the ship; though, of course, if any sort of structure is to be used on the outside, the mat may be kept in place *under* this and may thus continue to be efficient.

It might, for example, be practicable to construct a screen of planks to be hauled down over the outside of the mat and bound in place by lines around the ship and under the keel. If the hole is near the turn of the bilge, the planks might be seized together by short turns of rope passing through holes near the edges of the planks, these turns acting as hinges and making the screen sufficiently flexible to accommodate itself to the shape of the hull. A large piece of canvas—perhaps an awning—might be put on outside of all, and held in place by still other lines passed under the keel.

Having, by methods of this kind, checked the rush of water, it will usually be possible to build up a structure inside the ship which can be braced and caulked in such a way as to admit of proceeding to port.

If a water-tight compartment is to remain flooded, its bulkheads must be very securely braced from adjoining compartments.

CHAPTER XIV.

PILOTING.

§ I.

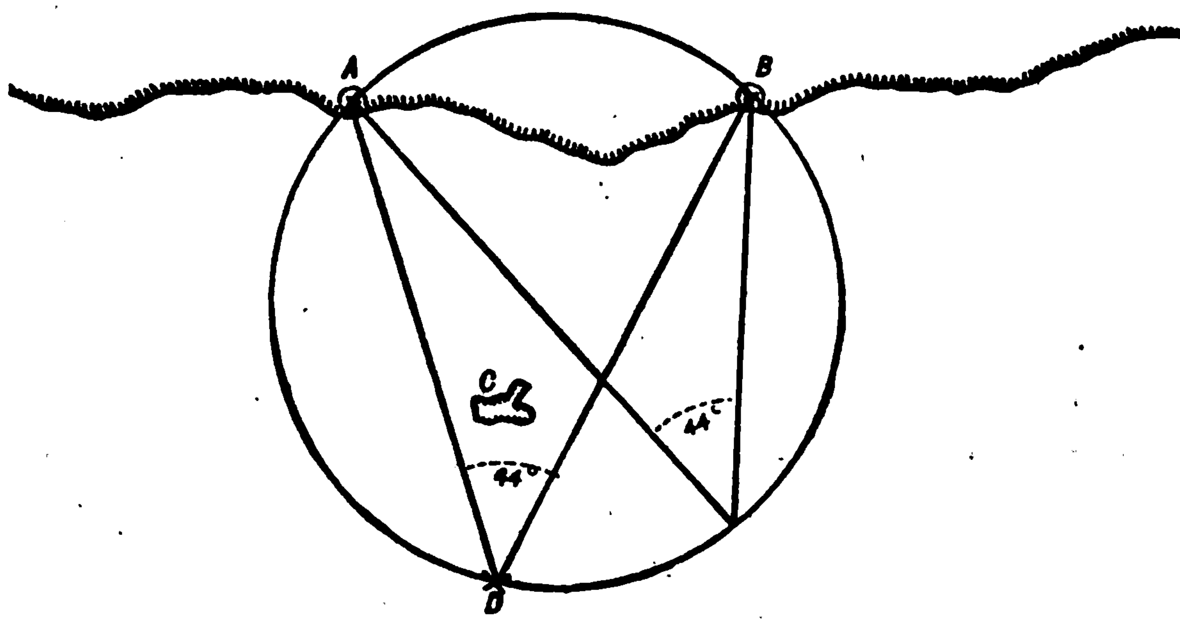
The navigation of a ship at a distance from land, sometimes known as "Proper Piloting" is not a matter of Seamanship. This chapter will therefore deal only with the handling of vessels in coasting and in navigating harbors and other restricted waters by the aid of soundings, buoys, lights, ranges, etc. For safe navigation under these conditions, it is important that the compass error should be accurately known, that reliable soundings should be had at frequent intervals, and that facilities should be provided for taking bearings quickly and plotting them accurately.

The compass error should be determined for the courses that are to be used in coming upon the coast, at the latest possible time. The leadlines should be examined and their marks verified.

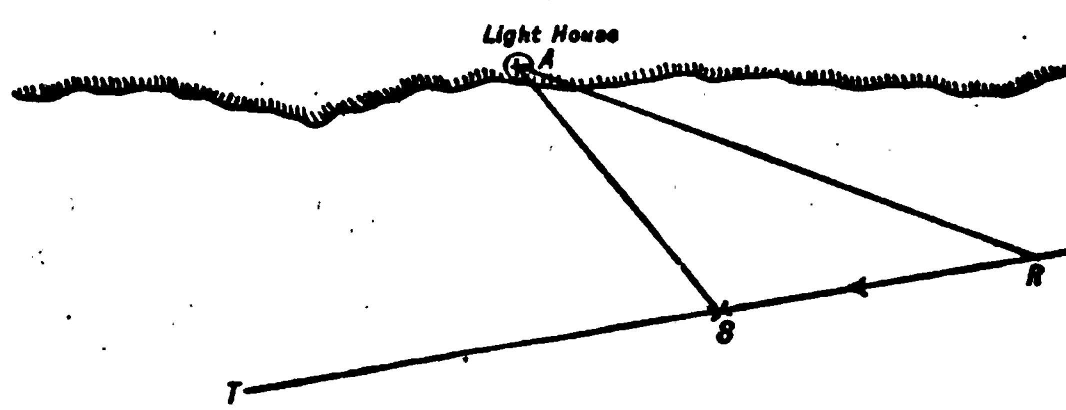
Good leadsmen are rare and time and trouble are well spent in training a few of them who can be relied upon when exact results are needed.

The Charts, Sailing Directions, Light and Buoy Lists, etc., should be studied and care taken that they are corrected to date.

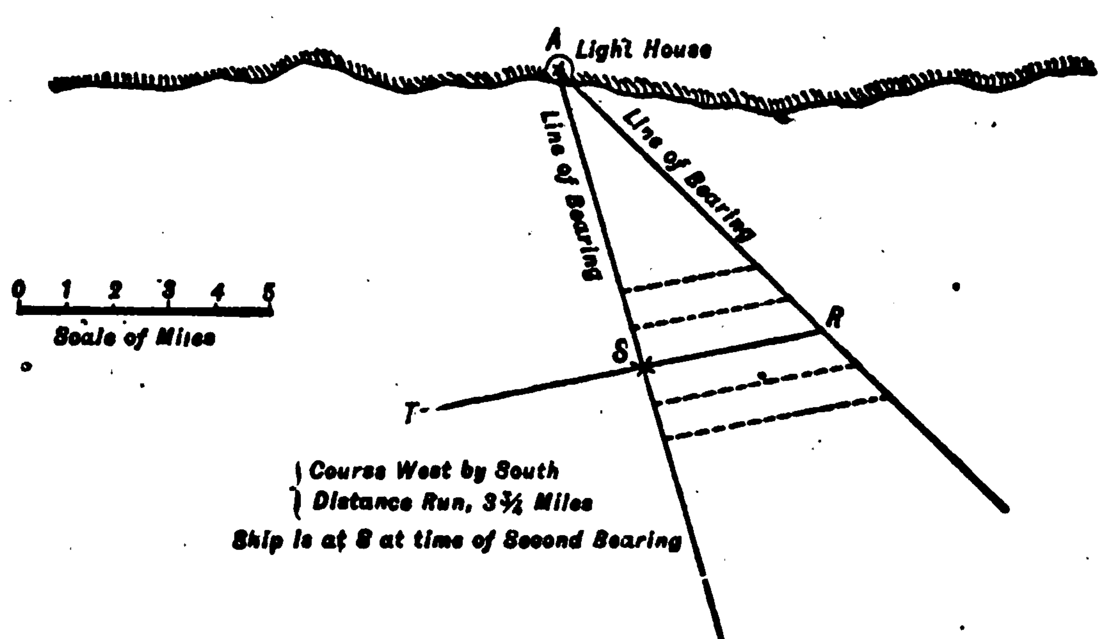
It is very desirable that the chart should be habitually kept on the bridge in pilot waters and for this it is convenient not only to have a large board permanently fixed on the bridge, but to use, in addition to this, one or more smaller portable boards to which the charts are tacked and which can be moved about at will. The use of two of these portable boards does away with the necessity of ever handling a loose chart on the bridge, as each chart can be tacked to its board in the chart-house and kept there until wanted. The portable board also does away with the necessity for going to the fixed board whenever it is desired to refer to the chart—a point which may be of great importance in a crowded channel.



Horizontal Danger Angle.
Fig. 1



Determining the Position by Two Bearings with the Run between.
Fig. 2



Fixing the Position Graphically by Two Bearings with the Run between.
Fig. 3

DETERMINING POSITION IN COASTING.

For taking bearings, the compass—fitted with a proper azimuth circle—is the most convenient instrument that can be used. When it is not available, the pelorus is substituted for it. (See chapter on "Compass, Log and Lead.")

Sextant angles are sometimes to be preferred to compass bearings, but are not as universally available. They are unquestionably more reliable than compass bearings where everything is favorable for their use, if only because they involve no such uncertain element as deviation; but they require three conspicuous and accurately charted objects separated by favorable angles; and these conditions are not very often to be found. All officers should, however, be familiar with the use of the sextant for measuring horizontal angles and of the three-arm protractor for plotting them.

Another convenient and valuable use of the sextant in piloting is for determining distances by the vertical angles subended by light-houses, etc., the heights of which are known.

Tables are published which give at a glance the distance of an object of a certain height corresponding to any observed sextant angle; but in the absence of such a table, it is not difficult to make the necessary calculation. A common application of this principle is the "vertical danger-angle." Having to pass a light-house or some similar object of known height, we decide at what minimum distance it shall be passed, determine the angle which it will subtend at that distance, and then, by frequent observation, make certain that the angle is not allowed to exceed this value.

Strictly speaking, the height of the observer's eye is a factor in this problem, but for ordinary purposes this may be disregarded.

Evidently the same angle enables us to keep at a safe distance *inside* of an outlying danger if we have to pass between it and the coast; and we may even work our way between two dangers in this manner.

The "Horizontal Danger-Angle is used where there are two well-defined objects in the vicinity of a hidden danger. In Fig. I, Plate **112**, suppose A and B to represent two promi-

[1] See the Chapter in Lecky's Wrinkles in Practical Navigation, on "The Station Pointer"—this being the English name for the three-arm protractor.

nent objects which are plotted on the chart, and C an outlying danger. At a safe distance to seaward of C, place a mark D, and draw a circle through A, B and D. Draw also the lines A D and B D and with a protractor measure the angle A D B. This angle is the "danger-angle." So long as the angle between A and B measured at the ship is less than A D B, the ship is outside the circle shown. If the angle becomes greater than A D B, she is within the circle. When it is equal to A D B, she is on the circle.

It is a well-known geometrical proposition that "all the angles inscribed in the same segment of a circle are equal." In other words, all the angles that can be formed by lines drawn from points in the circumference to the extremities of the chord A B will be equal to each other. As we pass inside the circle, the angles will increase; as we pass outside they will decrease.

In running along the land with prominent marks in sight, the position should be plotted frequently, as there is always danger that the ship will be set in by a current of which the chart and Sailing Directions give no hint. If two well-marked points are in sight, so placed that their lines of bearing "cut" at a favorable angle, the simplest method of fixing the position is by cross-bearings. If only one suitable object can be seen, its line of bearing may be plotted and an attempt made to fix the position of the ship on this line by an estimate of distance, by a sounding or by some other means. If the object seen chances to be a light just coming above the horizon (a common situation), its distance may be determined with considerable accuracy from its height and that of the observer's eye. It happens that the distance from any given height to the visible sea-horizon is, in miles, approximately equal to the square root of the height in feet. Thus, if an observer whose eye is 25 feet above the water-line, sees, *just on the horizon*, a light whose height he knows to be 100 feet, he will not be far wrong in assuming its distance as 15 miles.

For more exact results, the following table is convenient:

TABLE OF DISTANCES AT WHICH OBJECTS CAN BE SEEN AT SEA, ACCORDING TO THEIR RESPECTIVE ELEVATIONS AND THE ELEVATION OF THE EYE OF THE OBSERVER.

Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.	Heights in feet.	Distances in nautical miles.
5	2·565	70	9·598	250	18·14
10	3·628	75	9·935	300	19·87
15	4·443	80	10·26	350	21·46
20	5·130	85	10·57	400	22·94
25	5·736	90	10·88	450	24·33
30	6·283	95	11·18	500	25·65
35	6·787	100	11·47	550	26·90
40	7·255	110	12·03	600	28·10
45	7·696	120	12·56	650	29·25
50	8·112	130	13 08	700	30·28
55	8·509	140	13·57	800	32·45
60	8·886	150	14·22	900	34·54
65	9·249	200	16·22	1000	36·28

Example.—A tower, 200 feet high, will be visible to an observer whose eye is elevated 15 feet above the water, 21 nautical miles nearly: thus from the table:

15 feet elevation, distance visible 4·44 nautical miles.
200 " " 16·22 "

20·66

Abnormal refraction may introduce an error here. And on a coast where the rise and fall of the tide are excessive, neglect to allow for this might be a serious matter.

If the light is *above* the horizon, the observer may move downward until he finds the height that brings it to the water-line.

Two observations of a single object will give a "fix," if the course and distance run in the elapsed time are noted. In running on a steady course with such an object in sight we have a series of simple triangles formed by the intersection of the course with the successive lines of bearing (Fig. 2, Plate 112). In these triangles, we have given the side R S, representing the distance run between any two bearings, and the angles made by these bearings with the course; A R T and A S T. The triangles might, of course, be solved simply enough by ordinary mathematical processes, but these are not suited for work on the bridge. The table which follows gives the solution without calculation. It is a good plan to have a copy of this posted on a board and hung in the chart-house.

TO FIND THE DISTANCE OF AN OBJECT BY TWO BEARINGS, KNOWING THE DISTANCE RUN BETWEEN THEM.

Rule.—Under the number of points contained between the course and second bearing, and opposite to the difference between the course and first bearing, will be found a number which multiplied by the miles made good will give the distance of the object (in miles) at the time the last bearing was taken.

N. B.—Due allowance should be made for current.

Difference between the Course and Second Bearing in Points of the Compass.

Example.—A lighthouse bore WNW. The ship ran 6 knots, West, and the lighthouse then bore NW. ½N. Required the distance of the lighthouse at the time of the second bearing.

Angle between the course and first bearing = 2 points.
" " " " " second " = 4½ "
Multiplier from table = 0·81
Distance = 6 × 0·81 = 4·86 nautical miles.

In the absence of a table, the problem may be solved graphically by plotting the lines of bearing on the chart and determining by the aid of rulers and dividers where the *given course* must cut these lines to make the distance between them equal the run of the ship (Fig. 3, Plate 112).

There are several convenient applications of the above-described principles to practical cases, which call for neither a Table nor a Chart. If the second observation is taken when the angle between the line of bearing and the course (A S T) is exactly double what it was at the time of the first observation

(A R T), the distance of the ship from the object at the time of the second observation is equal to the run of the ship between the observations.

Again, knowing the distance A S, and the angle A S T, we may by reference to the Traverse Table, determine the distance at which the point A will be when abeam.

It will be understood that in all observations involving the run of the ship, allowance must be made for any current that may be known to exist.

If the first bearing is taken when the point A is exactly on the bow and the second when it is abeam, the distance at the time of the second observation will be equal to the run of the ship between observations. This method of fixing the distance from an object when abeam is called the method of "Bow and Beam Bearings" and is usually carried out with all prominent landmarks passed. There is no reason why both this method and the preceding one should not be made matters of routine and all observations connected with them entered in a "Coasting Record" to be kept in the chart-house.

In this connection, attention may be called to the importance of recording all observations accurately at the time they are made, and of noting the reading of the patent log for every observation that has to do with the navigation of the ship, whether this be a sight, a sounding or a bearing.

Advantage should be taken of every opportunity for getting a line of position by means of two objects "in range" with each other. This calls for no measuring of bearings and is at once the most convenient and the most accurate line that can be obtained. If, at the instant that the range is closed, a bearing of another object be noted, or the sextant angle measured between another object and the range, the position is fixed at once.

A convenient way of determining the compass-error for the compass-heading at the instant is to take the bearing of a well defined and accurately charted range.

As a general rule, where coasts are well charted, well lighted and well buoyed, the safest way to navigate them is to keep close enough to see and clearly identify the landmarks in regular succession, running from one mark to another with careful bearings on them all, taking advantage of every opportunity

to fix the position, and watching especially to see if the ship is being set in toward danger as she often will be by currents which, in many cases, there is no reason to anticipate. In this way, the position is always known within a few miles and it is much safer than to keep off so far that marks cannot be seen, until the time when it becomes necessary to close with the coast; for when this time comes, you may be far out of your reckoning and a little mistake in standing in may have serious results. Another reason for keeping hold of the marks is that if the weather becomes thick, you know your position with certainty up to the last moment and so have a "departure" upon which you can rely for running in the fog. It is needless to say that in a fog, dangers should be given a wider berth than in clear weather, but even in a fog it is safer to feel the way along by careful soundings and by the help of the sound signals provided for the purpose than to cut adrift from everything. (See Section III of this Chapter.)

On coasts which are not well surveyed, no chances should be taken.

It must be remembered that buoys are often out of place and that light vessels may be so; and every effort should be made to fix the position by means of permanent landmarks. Even when buoys, etc., are changed intentionally and with due notice, it may happen that the notice is not received. A vessel approaching New York some years ago at the end of a passage from the Pacific went aground in thick weather because Sandy Hook light-vessel had been moved (three months before) and notice of the change had not been received.

In approaching a harbor, it is important to know not only the state of the tide as to height, but the direction and force of the tidal currents that may be expected. (See Section II.) After the channel is actually entered, the direction of the current may be known from its effect upon buoys and upon vessels at anchor, and all indications of this kind should be carefully noted. It will rarely happen that the currents run perfectly true to the direction of the channel; and where they draw across, the ship will be set over to one side unless a proper allowance is made by heading a little higher than the course that is to be made. In cases of this kind it is very helpful to use a *range;* and if none is laid down on the chart an effort should be made

to pick one out ahead. The objects seen need not be recognized to be of use for this.

The line on which the ship is running should be laid down on the chart and the position plotted frequently by such means as are available. This will give warning if she sags to either side.

A ship handles better with the tide against her than when running with it. If obliged to come in with a fair tide, the speed should be kept as high as circumstances permit, to insure good control by the helm.

In approaching a strange harbor, there may be difficulty in recognizing the landmarks and aids to navigation as laid down on the chart. Under such circumstances the ship should be stopped, and if necessary anchored, until the situation is made out clearly. If in doubt about the reliability of surveys, or if the channel is not buoyed, it is well to send a boat ahead to sound it out and mark it temporarily. In running among coral reefs, danger may be made out from aloft at a considerable distance, and intricate passages may be threaded in this way in perfect safety, *provided the sun is at the back of the observer.*

On a coast where careful soundings have been made and charted, the sounding machine gives a valuable means of locating the position. This will be described in another section upon "Navigating in a Fog."

§ II. CURRENTS.

Perhaps the most serious danger connected with piloting is that arising from currents, the force and direction of which are not known. This danger is greater in a fog than under other circumstances, but is one that should be kept in mind at all times when navigating in the neighborhood of dangers.

In most cases there is no way of foretelling with certainty the direction and force of the current to be anticipated at a given place and time, but this ought not to be true of such currents as are *tidal* in their nature. These are closely connected with high and low water; but whereas very elaborate tables are published giving the time of high and low for all parts of the world, there is so little information published with regard to tidal currents that many of the people to whom such information would be of value, remain, after years of sea-faring, under the impression that "slack" water corresponds to "high" and "low," that a

falling tide is necessarily accompanied by a current running out, and a rising tide by one running in.

This is so far from being true that at many places high and low water correspond with the maximum strength of tidal current. This commonly occurs where a large basin is to be filled through a relatively narrow mouth, as in the case of Chesapeake Bay, and where a narrow body of water lies open to the sea at both ends, as in the English Channel.

"We must take care not to confound the time of the *turn of the tide stream* with the time of high water. Mistakes and errors have often been produced in tide observations by supposing that the turn of the tide stream is the time of high water. But this is not so. The turn of the stream generally takes place at a different time from high water, except at the head of a bay or creek. The stream of flood commonly runs for some time, often for hours, after the time of high water. In the same way, the stream of ebb runs for some time after low water.

"The time at which the stream turns is often different at different distances from the shore; but the time of high water is not necessarily different at these points.

"In the center of all open channels when the tide runs right through, the streams nearly invariably overrun the times of high and low water by about three hours. In such a locality the stream due to the flood will commence three hours before high water and continue to run for three hours after high water, in the same direction.

"In tidal rivers a modified form of the same phenomenon occurs, *i. e.*, the stream runs up for some time after the water has begun to fall, and runs down after the water has begun to rise."

"Near the sides of a channel of any width, and whose sides are shallow, the direction of the tidal stream is rotatory. On the left hand, looking up the channel with the flood stream, the direction of rotation is with the hands of a watch; and on the right-hand side, in the contrary direction in the following manner: At low water, the stream will be running down the channel; at half tide, it will be flowing toward the shore; and at half ebb, it will be ebbing directly away from the shore. In the upper parts of estuaries or tidal rivers, where shallow water prevails, the duration of the flood stream is commonly shorter than that of the ebb. The higher up the estuaries, the greater will this difference become. This is apparently due to the retardation of the advancing tide caused by friction over the shoals, and when the range of tide is great, the water becomes heaped in the lower part of the estuary, finally rushing up the higher part in a wave, which, in extreme instances, has a more or less vertical face and is called a "bore." The Yangtse, Amazon and Seine are cases in point. In such a case, the tide rises perhaps half its height in a few minutes and the whole duration of flood stream will be confined to two or three hours or even less, the remainder of the twelve hours being occupied by the downward or ebb stream." Whewell, "Treatise on Tides."

It is only on an open coast line or in a shallow basin that slack water corresponds with high and low.

In a basin like Chesapeake Bay, the wave of high water travels up until it reaches and is reflected back from the head of the bay. There results from this a rather complicated condition of affairs in the bay, with two points of high and two of low, water, with points of slack midway between the adjoining high and low.

In a place like the English Channel, which lies open to the tides at both ends, the currents flow from both sides toward and away from a certain point, which in the case of the English Channel is near Dover. In this case, moreover, *the tide turns throughout the whole length of the channel at practically the same moment.* Similar phenomena occur in Long Island Sound and East River, which constitute together a single body of water open to the tide at both ends. Here the tidal currents meet and separate at Throg's Neck. It is slack water at practically the same time along nearly the whole length of the Sound, and the same is true of East River, where it is slack at, approximately, one hour and twenty minutes after high and low at Governor's Island, the current running from both sides toward Throg's Neck for six hours preceding slack water high, and *from* the same point for the six hours between slack water high and slack water low.

Local conditions may greatly modify the rules as laid down above. The currents are always weaker near shore than in the middle of the channel, and often run in the opposite direction, sometimes with considerable force. A striking illustration of this is to be seen in Wallabout Bay, an offset from the East River (New York harbor) on which the New York Navy Yard has its water front. At the strength of the flood tide, when the current in the river is running up (to the northeast) with a velocity of several knots an hour, a strong counter current runs along the face of the "Cob-dock" at the Navy Yard. Between the two currents an eddy is formed, which, as the currents slack, flattens out, growing longer and narrower, and finally disappearing as slack water is approached. There is no corresponding phenomenon while the ebb current is running, although the contour of the river results in some puzzling irregularities in the direction of the current.

As has been pointed out in the extract from Whewell quoted above, tidal currents do not always run in and out along the same line, but in many places swing through a complete circle, running, at different stages of the tide, from every point of the compass. This is well illustrated at Charleston Entrance, South Carolina. Here the first of the flood runs to the southwest, the middle of the flood to west, and so on until it has worked around to a little east of north, at which point the flood ends. A little later the ebb current begins, running to northeast, turns to east by the middle of the ebb, and so works around to south, where it ends. Other very striking illustrations occur at various points in the neighborhood of the British Islands, and the adjoining coasts of Continental Europe, where the currents are strong and often apparently erratic.

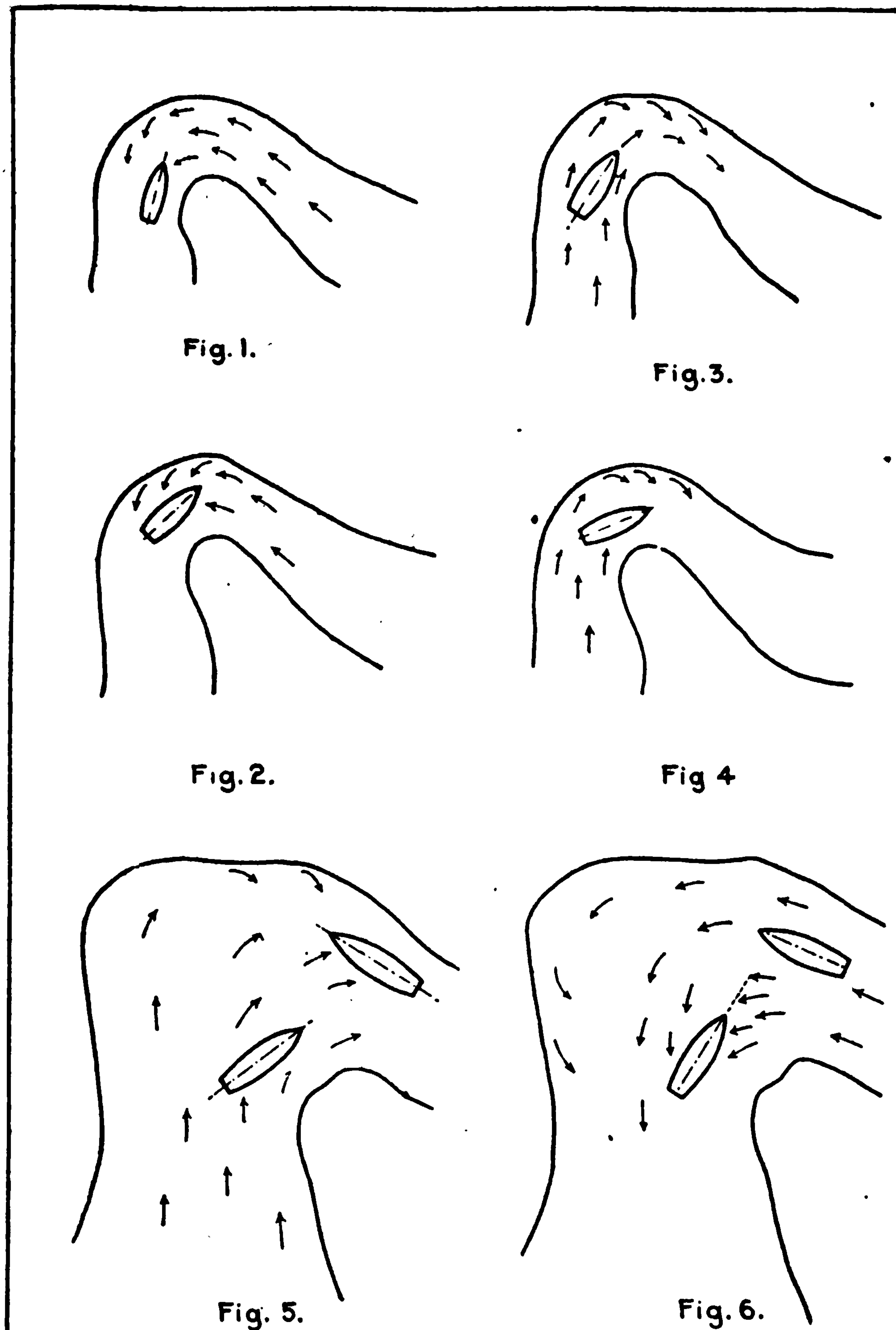
In so far as the currents of the British Islands are tidal in character, they have been very carefully studied, and the results are given in the "Tide Tables for British and Irish Ports," published by the Hydrographic Department of the British Admiralty.

Similar, though less complete, information for United States waters is published in the Tide Tables issued by the Coast and Geodetic Survey. All of this information should be familiar to officers having occasion to navigate the waters in question.

By far the most dangerous currents with which the navigator has to deal are those which, whether tidal or not in their origin, are encountered beyond the limits where tidal currents are usually looked for.

Opposite the mouth of a large basin like Delaware or Chesapeake Bay, the tidal current setting in or out is often felt many miles to seaward, and vessels in the neighborhood of such basins should be very watchful. Vessels passing twenty miles outside of the Delaware Capes have been set in toward the shoals by as much as three knots an hour, and there can be no doubt that this phenomenon accounts for many of the wrecks which occur every year along the coast of New Jersey, most of which occur where vessels are standing to the northward in thick weather.

In places where long shoals extend far out from land, there is almost always a current setting across. For reasons which are not clear, such a current almost invariably cuts in at more or less of an angle *toward the coast*. This has been frequently noted on



TURNING A SHARP BEND WITH AND AGAINST CURRENT.

Lookout and Frying Pan Shoals, off the coast of North Carolina, which are the scenes of frequent wrecks.

Where a long stretch of straight coast, like that from Hatteras northward to Cape Henry, would seem to preclude the probability of a current, there is often a very marked set, chiefly up or down, but always with a more or less pronounced tendency toward the coast.

These phenomena are the more dangerous because due to causes which are too obscure to be identified; being probably connected in some cases with gales or with long continued winds from a certain quarter, which have, perhaps, ceased to blow; or to winds prevailing farther to seaward and causing a general set toward the coast. The important point is that the navigator should always be prepared to find a current setting him in some direction whenever he is near a coast of any considerable extent, even though his Sailing Directions give no hint of such danger, and no reason for it is apparent.

Even when everything points to a current from a certain direction, there are many chances that it will be found running in some other direction. The Gulf Stream northwest of Cuba and in the Florida Straits—perhaps the most strongly marked ocean current in the world—is occasionally found running directly *across* the axis of the straits; and sometimes after a prolonged "Norther" may be found running south and west toward the Yucatan Channel and the Caribbean Sea.

It has been stated in § I that a vessel handles better when running against a current than when running with it. To this there is one exception. Where a sharp turn has to be made, the ship will make it better on a fair tide—in fact, it is dangerous to attempt such a turn against a strong head tide. This will be clear from Plate 113. In Figs. 1 and 2, a long steamer is shown attempting to round a turn against the current. As her bow reaches out beyond the point, it is caught by the current on the wrong side, and swept off the wrong way, giving her a rank sheer across (Fig. 1). A moment later her stern feels the back water sweeping out from the far side of the bend, and tending to cut her stern around the wrong way. Thus there are two forces at work, one on the bow and the other on the stern, to keep her from making the turn. In Figs. 3 and 4 are shown the corresponding forces when the tide is fair. Here everything favors the turn, and it is difficult to keep the ship from coming around.

Some years ago, a large schooner anchored in the Piscataqua River below Henderson's Point, parted her cable in the middle of the night and went up the river with a five-knot current. At that time the river made a narrow right-angle bend around the Point, and the turn was regarded as difficult enough under the most favorable conditions. The schooner, with all hands on board asleep, rounded the point without touching, and brought up on a shoal a mile and a half further up the river.

Where two ships are passing at a bend, it will be easier for them to pass clear if the one going with the current turns inside the other. This does not mean that they are privileged to pass in this way, if contrary to the Rules of the Road, nor indeed that they are justified in trying to pass at a bend in this way or in any other. If, however, they are going to pass, and if the rules permit them to pass in this way, it will be comparatively easy to pass without accident while the other way would be very dangerous. See Figs. 5 and 6, Plate 113.

§ III. NAVIGATING IN A FOG.

The phase of this subject which has to do with the avoidance of collision is fully discussed in Chapter "Manœuvring to Avoid Collision," where it is shown that the law requiring ships to run at "moderate" speed is perfectly reasonable as a matter of seamanship, and that a ship running at such speed, and having, as she should have, a reserve of power for backing hard, can be stopped in from one to three times her length. It is clear that the same considerations which make this reasonable for the avoidance of collision make it equally so for the avoidance of stranding; but there is another point to be considered here, which is that the effect of currents in throwing the ship out of her reckoning will be greater at a low than at a high speed, their effect varying, in fact, inversely with the speed. This should always be taken into consideration and may under some circumstances constitute a reason for running at higher speed than would otherwise be justifiable.

Experiments with fog-signals have proved that such signals are often inaudible at distances much within that at which they should be heard; and furthermore that a signal which has been heard at a certain distance may be lost *as it is approached,* there being, apparently "zones of silence" surrounding the signals, in which the waves of sound are deflected upward. This has been shown to be a matter of sufficient practical importance to be a source of real danger.

Plate No. 114.

SIGNIFICANT SOUNDINGS. FIXING POSITION IN A FOG

With an exact knowledge of the errors of the patent log and the compass, the dangers of fog are greatly reduced, but the most important element of safety is the modern sounding machine described in Chapter VI. This machine is used without reduction in the speed of the ship and gives results which are almost absolutely accurate. If the soundings are taken frequently and plotted on a piece of tracing cloth, with the courses and distances between, the position of the ship may often be fixed with surprising accuracy by moving this tracing over the chart until a position is found where the soundings as plotted fall in with the depths given on the chart. It is convenient to draw a number of meridian lines on the tracing-cloth as an assistance in laying off the courses and in keeping these true to the chart while moving the tracing about. The lead is "armed" for each sounding and the sample of bottom brought up should be recorded as carefully as the depth, and given equal weight in locating the position.

It will be understood, of course, that this method of navigating is available only on coasts that have been thoroughly surveyed and accurately charted.

An examination of the chart will often reveal an exceptional formation of the bottom which may be as characteristic as a conspicuous peak or other peculiar formation on land, and as conclusive in establishing a position. Two important illustrations of this are shown in Plate **114**. Fig. 1 shows the soundings at the eastern entrance of Long Island Sound. Here a long, narrow "deep" makes up at right angles to the line connecting Montauk with the southern end of Block Island.

A vessel standing in here in a fog and in doubt about her exact position, could run slowly to the eastward in 7 and 8 fathoms, getting soundings in quick succession. If the soundings increased suddenly from 7 fathoms to 25 or 30, and immediately afterwards decreased almost as suddenly, the position would be fixed as if the fog had lifted and shown the land. Similarly, a vessel standing in for Boston and getting soundings on Stellwagen Bank, would have almost a perfect fix (Fig. 2).

It often becomes necessary in a fog or in weather too thick for sights, to run along a coast or to round a bend, keeping at a certain distance from land. Where the soundings run with some degree of regularity, as for example, along the Atlantic

coast of the United States, a certain depth of water (or two limiting depths) may be selected from the chart and the ship kept approximately on the curve of this depth by heading out or in a little as the soundings are found to decrease or to increase. Thus a steamer having to run in thick weather from Boston to Key West could round Nantucket shoals in depths from 28 to 35 fathoms, then striking across to the 20-fathom curve on the coast of New Jersey could follow this curve with safety to Cape Canaverel.

In running a channel where the water shoals gradually on each side, the ship may be kept in the channel by zig-zagging slightly from side to side, the course being changed whenever the water is found shoaling dangerously. The advantage of running more or less across rather than attempting to follow the channel directly is that when the water begins to shoal, we know in which direction the course must be changed to deepen it, whereas if we attempt to follow the channel, and find ourselves in shallow water, we have no means of telling on which side the channel lies.

When in the neighborhood of high land, use can sometimes be made of *echoes* to determine roughly the distance of the land and whether the ship is opposite a bluff or a break in the contour of the coast.

§ IV. BUOYAGE.

The International Marine Conference of 1889 suggested a uniform system of buoyage based first upon color and secondarily upon shape. The following extract from the report of the committee having this subject in charge, puts very clearly the principles which should be included in such a system. These principles have been to a considerable extent adopted by the leading commercial nations of the world, as will be seen in the appended Notes on Buoyage.

Extract from Report of Committee on Buoyage:

"The term starboard hand shall denote that side of a navigable channel which is on the right hand of the mariner entering from seaward; the term port hand shall denote that side which is on the left hand under the same circumstances.

Color.—Buoys defining the starboard hand shall be painted a single red color.

Buoys defining the port hand shall be painted a single black color, or a parti-color.

Buoys defining middle grounds shall be painted with horizontal bands.

Form.—Wherever form is used as a distinctive character.

Buoys defining the starboard hand shall be conical, and those defining the port hand shall be can or spar.

Top Marks.—Countries where form is not used as distinctive character for the buoys may adopt as another distinctive feature for the buoys on either side of a channel, top marks resembling a cone to be used on the starboard side, or a cylinder on the port side of a channel.

Numbers and Letters.—Numbers, letters and names may be painted on the buoys, but they must never be so large as to interfere with their distinctive coloring.

Whenever numbers and letters are used they shall be in consecutive order, commencing from seaward.

Buoying and marking of wrecks.—(a) All buoys and the top sides of vessels used for the marking of wrecks, shall be painted green with a suitable white inscription.

(b) Where it is practicable, by day one ball shall be exhibited on the side of the vessel nearest the wreck, and two placed vertically on the other side; three fixed white lights similarly arranged but not the ordinary riding lights, shall be shown from sunset to sunrise."

It should be observed that the above are recommendations and not laws. As a matter of fact, however, the general features of these recommendations have been adopted by most of the Governments which have established uniform and consistent systems of buoyage.

As regards the marks for channels, some nations distinguish the starboard and port sides by color, some by shape, and some by topmarks. Some use two characteristics, but place more emphasis on one than on the other.

In German waters, *conical* buoys painted black, mark the port side of the channel in entering, and spar or *can* buoys painted red, mark the starboard side.

In Norway, Sweden and Russia a "*compass*" system of marking is adopted; that is to say, the colors, shapes and topmarks are arranged to indicate the north, south, east and west sides of channels and shoals.

Quarantine buoys are invariably yellow.

Buoys defining the limits of anchorages are usually white. But Belgium, Norway, Sweden, Russia and Denmark use white buoys as regular navigational marks.

In all countries, special types of buoys, beacons, etc., are used in special places and shown on charts. Such are Bell-buoys, Whistling-buoys, Gas-buoys, Electric-buoys, etc.

In regular systems, starboard hand buoys, if numbered, have even numbers, port hand buoys, odd numbers, counting in succession from seaward.

In the Straits of Magellan and the Patagonian Channels, the buoys are placed with reference to vessels passing from the Atlantic to the Pacific, red buoys being on the starboard hand of the channel with reference to such vessels and black buoys on the port hand.

The positions and character of buoys should be given on all charts and in all Sailing Directions, and the latest authoritative information available should always be consulted before entering or leaving a port or coming on a coast.

Buoyage of United States Waters.

The following are the rules for the buoyage of the coasts and harbors of the United States and Insular possessions:

The buoys used for marking channels, dangers, etc., are called nun, can, ice and spar buoys. With the exception of the spar buoy, which is made of wood, they are constructed of sheet iron with water-tight compartments so that an accidental puncture will not sink them.

In conformity with section 4678 of the Revised Statutes of the United States, the following order is observed in coloring and numbering the buoys along the coasts, or in bays, harbors, sounds, or channels, viz.:

1. In approaching the channel, etc., from seaward, **red buoys**, with **even numbers**, will be found on the **starboard side** of the channel, and must be left on the starboard hand **in** passing in.

2. In approaching the channel, etc., from seaward, **black** buoys, with **odd numbers**, will be found on the **port side** of the channel, and must be left on the port hand in passing in.

3. As a rule, starboard hand buoys are *nuns*, and port hand buoys *cans*, but spars may replace either.

4. Buoys painted with **red and black horizontal stripes will** be found on **obstructions**, with channel ways on either side of them, and may be left on either hand in passing in.

5. Buoys painted with **white and black perpendicular stripes**, will be found in **mid-channel**, and must be passed close-to to avoid danger.

6. All other distinguishing marks to buoys will be in addition to the foregoing, and may be employed to mark particular spots, a description of which will be given in the printed list of buoys.

7. **Perches**, with balls, cages, etc., will, when placed on buoys, be at **turning points**, the color and number indicating on which side they shall be passed.

8. Day beacons, stakes and spindles (except such as are on the sides of channels, which will be colored like buoys) are constructed and distinguished with special reference to

each locality, and particularly in regard to the background upon which they are projected.

9. Wherever practicable, the towers, beacons, buoys, spindles, and all other aids to navigation are arranged in the buoy list of the Lighthouse Board in regular order as they are passed by vessels entering from sea.

10. The navigator should keep in mind that the buoys in thoroughfares and passages between the islands along the coast of Maine are numbered and colored for entering *from the eastward.*

Plate No. 115.

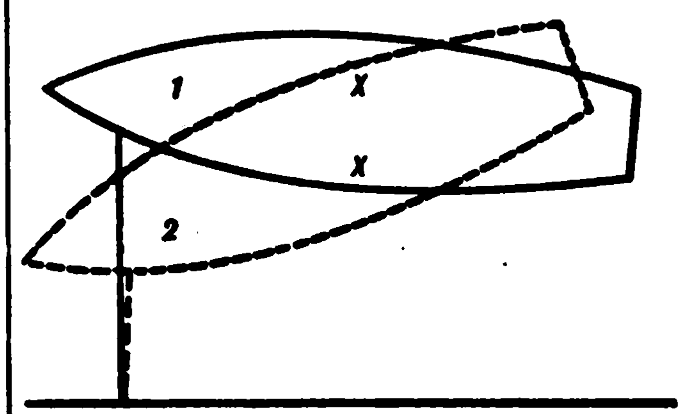


Fig. 1

Fig. 2

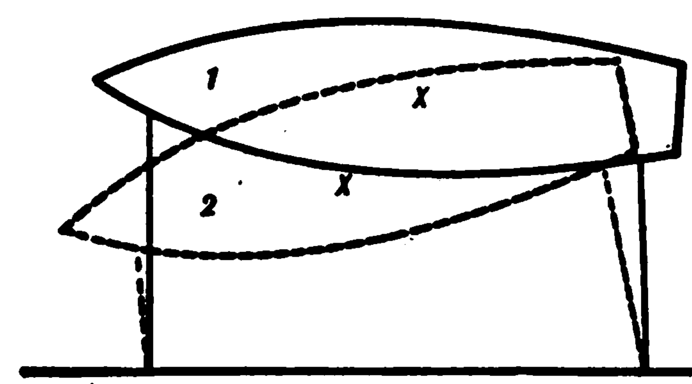


Fig. 3

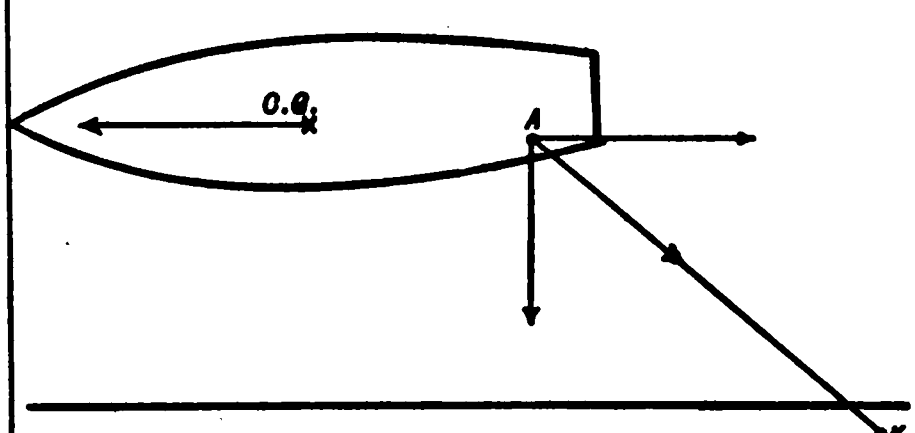
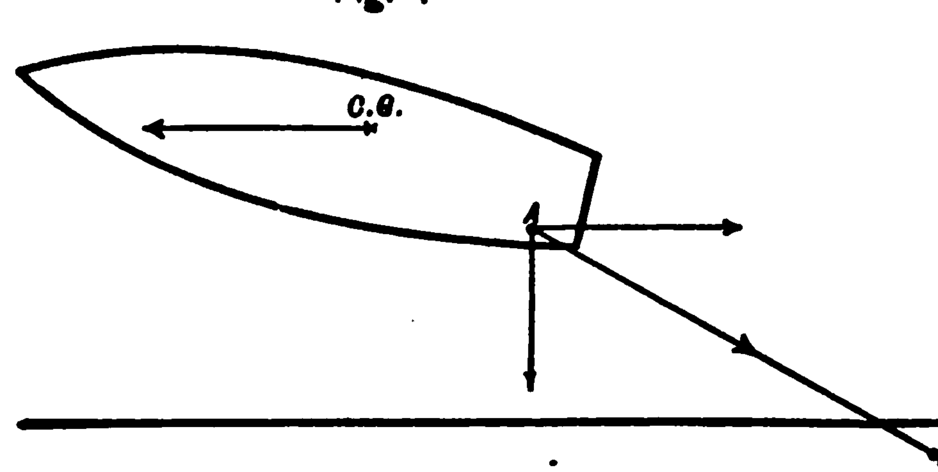


Fig. 4



HANDLING STEAMERS AROUND A DOCK.

CHAPTER XV.

HANDLING A STEAMER ALONGSIDE A DOCK.

§ I. PRELIMINARY.

It is clear that the conditions under which work of this kind is to be done may vary almost indefinitely and that the methods used must be varied correspondingly. It would be hopeless to attempt to illustrate all or even any considerable number of the situations which arise in practice, but it is not so difficult to analyze in a general way the various factors involved, and to show their application to a few special cases.

The factors are: lines, helm, screw, headway or sternway of the ship, current, wind.

We begin by considering the use of lines, first alone, then in combination with other factors.

CASE I.

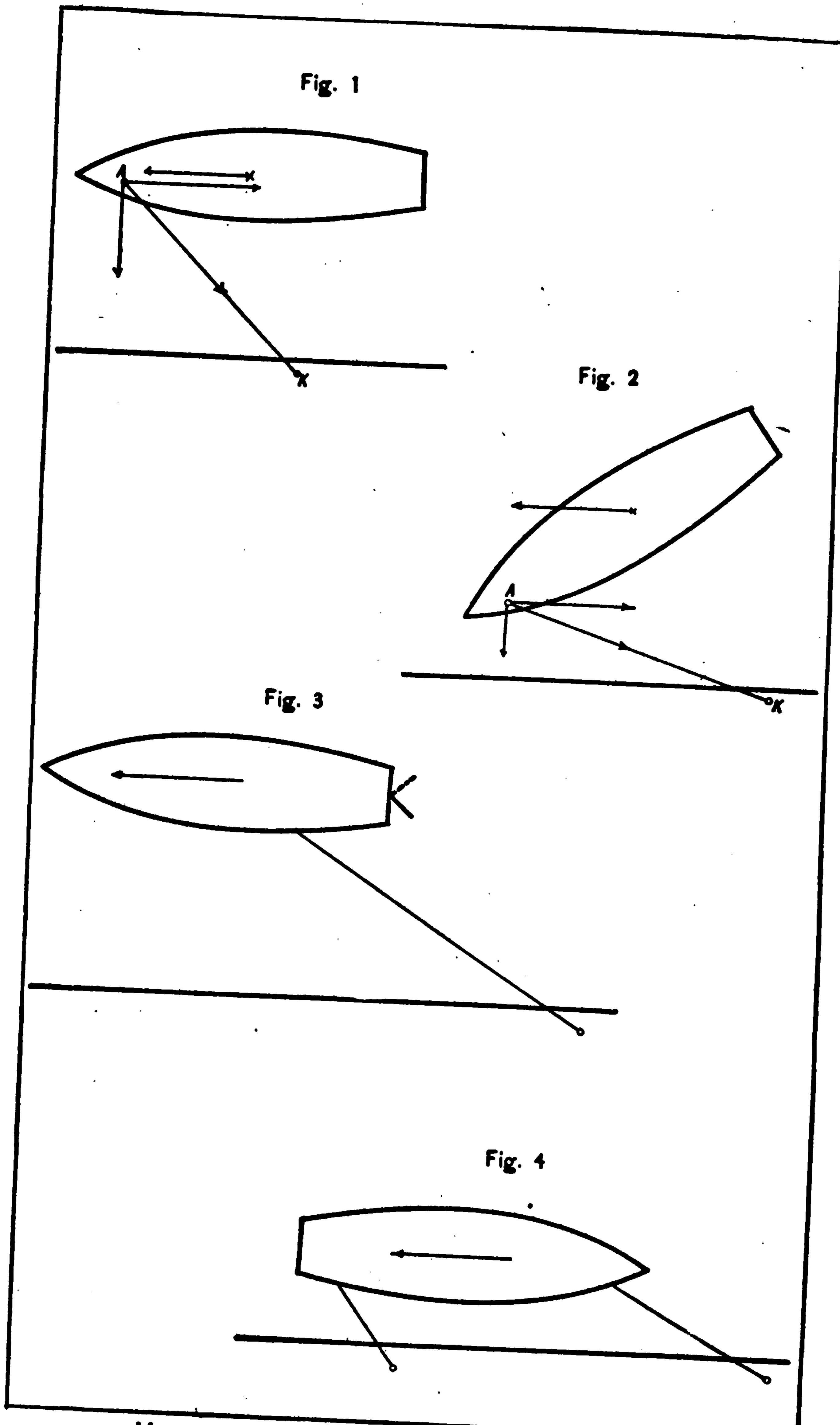
If the ship is lying dead in the water abreast of a dock, as in Fig. 1, Plate 115, with a bow line leading to the dock, hauling on this line will turn the bow in, of course, but it will also throw the stern out, the ship pivoting about the center of gravity. It should be noted, however, that the stern does not go out quite as much as the bow comes in; for, since the ship is not held rigidly at the pivoting point, the mass as a whole will respond more or less to the force acting on the bow, and the resultant motion will be like that shown in the figure.

If the stern is held by a line to the dock, as in Fig. 2, Plate 115, the pivot is transferred to the stern and the whole length of the ship comes in as shown. This requires much greater effort than to turn the ship about her natural pivoting point as in Fig. 1.

If the bow and stern lines are hauled on at the same time, the ship may be breasted in bodily, but at an even greater expenditure of work than in the preceding case.

If either of the lines described above leads off at an angle from the beam, it constitutes a "spring," which may be defined as a line diagonal to the keel and exerting a force, when power is

Plate No. 116.



HANDLING STEAMERS AROUND A DOCK.

applied to it, both in the direction of the keel and at right angles to that direction.

A spring is used, therefore, for moving the ship ahead or astern and breasting her in at the same time.

CASE 2.

If the ship has way, either ahead or astern, her *momentum* enters into the problem of her behavior. We have here another application of a spring, the power involved in this case being furnished by the ship itself.

In Fig. 3, Plate **115**, suppose that the steamer shown is moving parallel to the face of the dock with engines stopped and helm amidships, and that the stern spring A K is taut. Disregarding the resistance of the water, which is inconsiderable, the motion of the ship will be that resulting from her momentum along the original course and the tension along A K. The tension on A K may be resolved into two components; one retarding the ship along the line of her original course and thus directly opposing the momentum, the other hauling her in toward the dock and tending at the same time to turn her about the center of gravity, drawing the stern in and throwing the bow out. It is important to note, however, that the momentum, which is concentrated at the center of gravity, *forward of the pivot*, opposes the turning and tends to keep the ship straight. Thus as a matter of fact the ship does not turn much in cases of this kind, but comes in nearly parallel to the dock (Fig. 4, Plate **115**).

CASE 3. (Figs. 1 and 2, Plate **116**.)

If the vessel is moving as before, but with a spring from the bow instead of from the stern, the forces acting are similar to those in the preceding case, but with an important difference. In the present case, the momentum acts to increase the turning effect of the spring, instead of opposing it. This will become clear if Fig. 2, Plate **116**, and Fig. 4, Plate **115**, are compared.

The result of this difference is that the *bow* of a ship moving ahead on a bow-spring turns sharply in toward the dock, whereas the stern is turned in very little, if at all, by a stern-spring.

If the ship is moving astern, instead of ahead, the conditions are of course reversed, a stern-spring turning the stern in sharply, while a bow-spring has little effect.

Evidently, in both of the preceding cases, the turning moment is greatest when the line is made fast at the extreme bow or stern. If it is made fast at the center of gravity, the ship should (theoretically) spring in without turning, provided her draft of water is the same forward and aft. We shall presently see that if the helm is to be used (as in practice it always is) the maximum contrcl of the ship will be obtained when the line is made fast at some point intermediate between the end of the ship and the center of gravity.

CASE 4.

Suppose that the vessel of Case 2 (Figs. 3 and 4, Plate **115**) puts her helm to starboard with a view to throwing her head in. Since the steering effect of the rudder is chiefly a matter of moving the stern of the ship, and since the stern cannot be thrown off to starboard because it is held by the spring, it follows that starboard helm can here have comparatively little turning effect. This assumes, of course, that the line is made fast over the rudder. Port helm, on the other hand, will help materially to throw the stern in.

If in Case 3 (Figs. 1 and 2, Plate **116**) the helm is put to starboard, it will throw the stern off and greatly increase the rapidity with which the bow turns in. If put to port, it will oppose the turning, but not enough to overcome it.

If in any case we make fast the line at the center of gravity while the ship is working ahead, we shall spring the ship in bodily but can at the same time *steer* her by putting the helm over, throwing the stern to either side as desired; the ship swinging on a pivot under the influence of the helm, while coming bodily in on the spring.

If the line, instead of being made fast amidships, is taken to a chock between the midship point and the stern, say midway between, we gain a considerable steering power, without entirely sacrificing the turning tendency of the spring. In practice, the spring is usually taken to this point—or to the corresponding one between the midship point and the bow—and this is found to give a convenient balance of forces and to admit of working in with the ship under good control (Fig. 3, Plate **116**).

CASE 5.

If we add to the factors already considered, the effect of the screw, going ahead or backing, we have the conditions of actual

practice in cases where the tide is not strong enough to be considered.

So long as the screw is turning *ahead* it has a powerful steering effect through the action of the discharge current against the rudder, driving the stern off to the side to which the helm is put, the bow being held in by a spring. In *backing*, its effect may be utilized to throw the stern to one side, but not to the other. If it is right handed, it will throw the stern to port and cannot be prevented from this even by hard over port helm. It is for this reason that single-screw steamers (right handed) are most easily put alongside with the port side to the dock. They can run in at a considerable angle, then stop and back and so straighten up parallel to the dock, whereas with the starboard side in, backing would throw the stern further off.

Vessels with twin-screws have the same advantage in working around a dock that they have in manœuvring elsewhere; that is to say, the screws can be utilized to turn the ship even when she has no steerage-way, and when, therefore, the rudder has little effect. This use of twin-screws—going ahead on one and backing the other—is obvious enough; but there is another application which can be made of them which is often overlooked. As noted above (and as explained at considerable length in the chapter on "The Steering of Steamers"), a right-handed screw, in backing, throws the stern to port, while a left-handed screw throws it to starboard. In a single-screw steamer we have, in this action of the backing screw, a powerful force acting to one side, which may be utilized with great advantage *if we wish to throw the stern to that side.* If it happens that we wish to throw the stern to the other side while backing, or to hold it steady, then this action of the screw is a disadvantage, and often a serious embarrassment. But in a twin-screw steamer we have *both a right-handed and a left-handed screw,* so that we may, in backing, throw the stern to either side by using the proper screw. It is the general practice to put the right-handed screw to starboard and the left-handed screw to port. If, therefore, we wish to throw the stern to port while backing, we back with the starboard screw alone; and it should be noted that not only does the direct action of the screw throw the stern to port, but the leverage due to the position of the screw (to starboard of the center of gravity) acts in the same direction. Similarly, if we wish to throw the stern to starboard, we back on the port screw alone.

Effect of a Current.

If there is any current, it must of course be reckoned with and may be the most important factor in the situation because the one which cannot be controlled. Slack water is the most favorable time for working around the dock; but a head tide, if not too strong, may be used to advantage. A fair tide is unfavorable, and should be avoided if possible in coming alongside. A weak tide setting on to the dock may be helpful, but a strong one is very dangerous. A tide setting off increases the difficulty of the situation, but reduces its danger.

In considering the effect of the tide, it must be remembered that a vessel with a current on the bow not only has her headway checked, but is set bodily off to the opposite side. For this reason, care must be taken to avoid getting too much of a cant across, as this may result in being set in with dangerous violence.

A ship held stationary in a current, whether by her own power or by a line, may be canted to either side by the use of the helm, exactly as if she were moving through the water. Thus, with a head tide, a line may be run out from the bow to the dock well ahead, and the ship dropped in by the tide alone, the speed with which she comes in being regulated by the helm.

§ II. PRACTICAL CASES.

In considering the handling of a steamer around a dock, a distinction must be made between the case in which she uses her own power alone and that in which she is assisted by one or more tugs. All very large vessels are now handled by tugs and it would be the height of imprudence to attempt to dispense with them. But vessels which would formerly have been considered very large are constantly worked in and out with their own resources alone. Such are the splendid vessels of the Sound and Bay Lines of the United States, some of which are side-wheelers and others propellers. These vessels run on schedule time and without reference to tides. They are brought alongside their piers often under the most unfavorable conditions, and rarely meet with an accident. It should be noted, however, that these vessels are especially designed for this business of docking under all conditions of wind and tide. Most of them have guards extending much farther out from their sides than anv of the projections which might interfere with docking.

The Marine Superintendent of one of the large Atlantic steamship companies writes to the author on this subject as follows:

"In my opinion, the great secret in handling either a twin-screw or single-screw steamer in approaching a pier, is not to have too much way on the ship; the engines should be slowed and the way off the ship so that she can be kept well in hand at such a distance from the pier, that if it should be necessary to go ahead in order to cant the ship's head either one way or the other by the use of the rudder, it can be done without the ship's overrunning the place where she is required to land. The ship should be kept thus in command until she gets into a position where she can be stopped entirely by moving the engines astern, without risk of her bows striking the pier, or of her getting out of position by her head canting off by the action of the propeller moving half or full speed astern. If the pier is approached in this manner, after a little practice it is astonishing how close even the largest vessels can be brought to the pier without danger of colliding. Large steam vessels should always approach a pier against the tide, and as near parallel with the direction of the tide, or trend of the river, as possible. The practice of heading a ship from the river between two piers is a very doubtful and frequently dangerous operation; for, although the tide may be slack on the surface it may be running smartly either flood or ebb for a few feet below."

Handling a Steamer without Tugs.

Having to go alongside, if there is any choice in the matter, select a time as near as possible to slack water; which, it must be remembered, does not necessarily or usually correspond to high or low. If any current is running, manœuvre if possible to bring it ahead, running beyond the pier and turning if coming in with the flood. With a single-screw steamer, there is an advantage in putting the port side to the dock (supposing the screw to be right handed) but this is of less importance than is the direction of the tide.

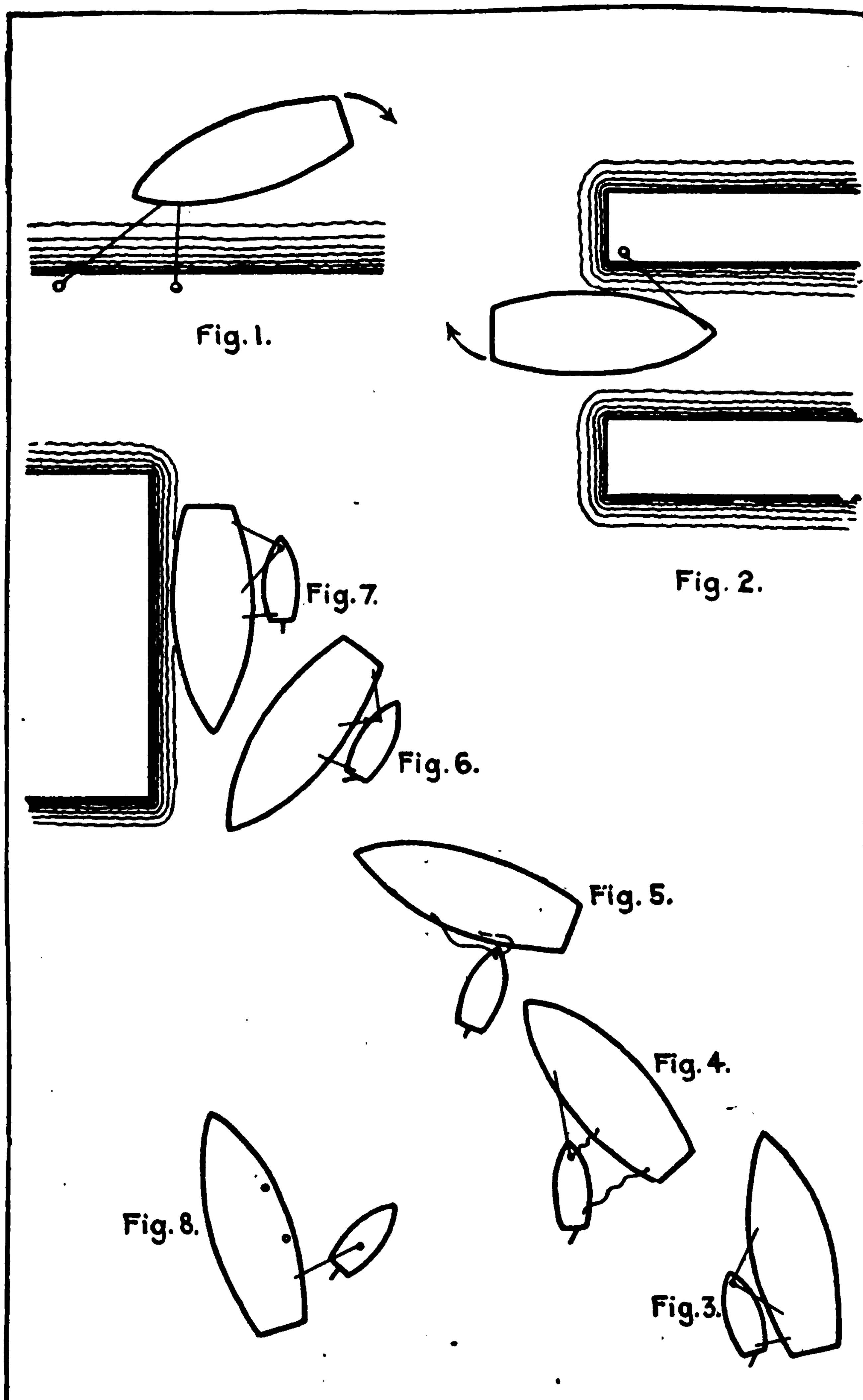
A vessel does not go alongside without some preparation having been made, and there are usually men stationed to receive and handle her lines. If not, a gang must be sent ashore for this purpose; and in any case, a boat should be ready for lowering, with the men either in it or standing by. Fenders should be at hand, lines on deck and clear for running, with heaving lines

bent, anchors ready for letting go, capstans and winches ready for heaving, boat-davits and every thing else alongside rigged in or cleared away as far as possible. Most merchant vessels are designed with some reference to going alongside, although it is impossible in any ocean-going vessel, to avoid the projection of boat-davits and some other obstructions. In men-of-war there are also guns and sponsons to be considered; and in twin-screw ships, whether men-of-war or merchantmen, the screws project many feet beyond the side and constitute a danger which must never be forgotten for a moment. To keep these vessels off, there are usually provided floats or "camels"; and these must be hauled into position by the shore gang at the points where they are seen to be needed.

The simplest case that can arise is that in which a right-handed screw vessel is to be put alongside at slack water and port side to the dock. Here she is run in at a small angle to the face of the dock, and the engines backed in time to throw her stern in and straighten her up. This does not mean that she should come in at such speed and at such an angle that if the signal to back is misunderstood or if the engines are slow in responding, the bow will crash into the dock. Other things being equal, the more nearly parallel to the dock she is brought in, and the lower the speed used, the better; but as some backing will probably be called for and as the effect of this will be to throw her stern in, a little allowance should be made for it.

Another way of making a landing under the above conditions is to get out a line from the quarter, and, going ahead very slowly, spring her in on this, using the helm to hold her parallel to the dock. A line used in this way must be carefully attended and checked slowly as the tension on it approaches the danger point. It should preferably be taken from a chock about half way between the midship point and the stern, as this gives good control of the ship by the helm as she comes in.

Under the same conditions, if the port side is to the dock, she might be sprung in by backing on a bow line, but this is not so good a way, since the control of the ship in backing is altogether unsatisfactory. If the starboard side is to the dock, the effect of backing would be to throw the stern off, so if this method is to be used, a stern spring will be needed in addition to the bow spring (Fig. 4, Plate 116). The use of two springs like this is very common.



WORKING AROUND A DOCK, TURNING A TOW.

A *twin-screw* ship may be backed down on a bow line and sprung in with comparative ease, the helm being used to keep her fair with the dock, and the right- and left-handed screws used as has been explained above.

Here it will be helpful to use a bow-breast with the spring as in Fig. 1, Plate 117, coming in with a decided cant toward the dock, and getting the lines to the dock as shown, the breast being taken from as far forward as is convenient. Now by backing on the off screw we drop alongside.

It sometimes happens that a ship is going into a slip with very little room, as in Fig. 2, Plate 117, and it becomes necessary *to check her without canting her.* The bow spring shown, if used alone, would cut her bow in sharply. Here we may check her with two forces which will act together for checking her way, but oppose each other for canting. These are the spring on the inner bow, and the screw (backing) on the outer quarter. This is often a very valuable combination of forces.

If there is a head tide, the vessel may be brought up with hardly more than headway enough to stem it until a bow spring is run, then allowed to drop back on this by the tide and so come in to her berth. Care will be needed to see that she does not get too strong a cant across, as this would set her in with dangerous force. She can be steered without difficulty by the helm, giving a turn ahead with the screw if necessary from time to time. In this way a vessel may drop in from a considerable distance out. She may even dispense with the line for coming in, taking the tide a little on the bow and letting this set her in bodily; care being taken, as before, that she does not come in too fast, the helm and engines being used to straighten her up when necessary.

It does not always happen that the tide sets parallel to the face of the dock. More frequently, it sets on at more or less of an angle, and the angle often varies with the stage of the tide. At Old Point Comfort, for example, the current at one stage of the ebb runs along the face of the dock, while at another stage it sets directly on. Between the two extremes, it turns slowly from one of these directions to the other. Similar phenomena to this are common in all places where fairly large bodies of water are involved and especially where the channel bends or where several channels meet. Another point to be remembered is that the surface current often has a very different direction from that

which is running underneath. Considerations like these make it clear that local knowledge is essential for docking ships with safety, and suggest that in places where the phenomena of currents may prove to be complicated, a stranger having to dock his ship should seek the assistance of a pilot with full knowledge of local conditions.

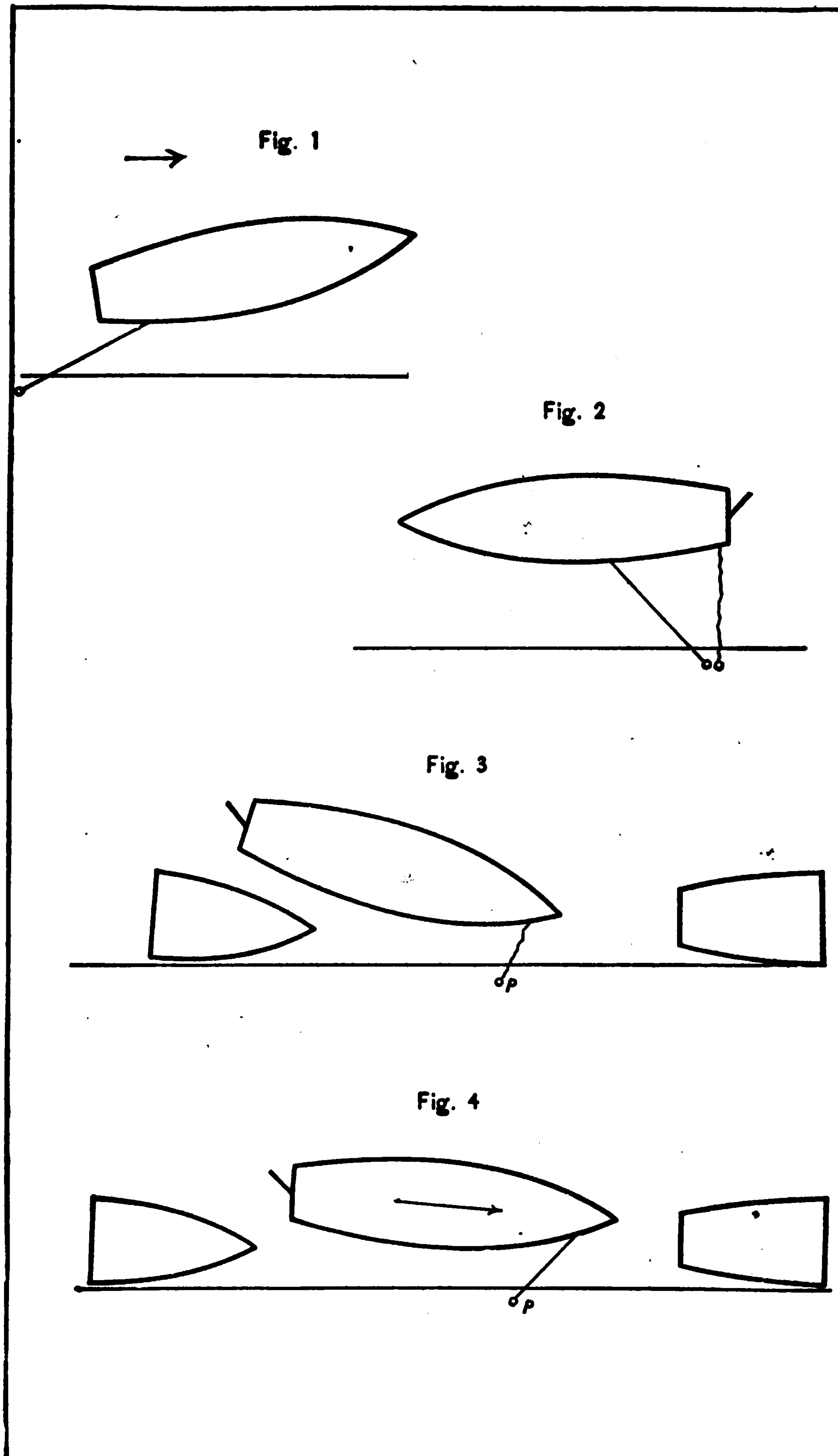
If it should be necessary to make a landing with a fair tide, preparations must be made to get out a stern line promptly, and the vessel should be brought abreast her berth (or a little astern of it) *with a slight cant of the head outward* (Fig. 1, Plate 118). This will prevent danger of the current catching her stern on the inside and sweeping her off while the line is being made fast, as might happen if her head were canted in.

It is an invariable rule that with a fair tide, the ship must be sprung in with a stern line, never with a bow line alone; and the same rule applies in springing her in by her own headway. In either of these cases, the effect of a bow spring would be to throw the stern off, while a stern spring, for reasons which have been explained in Section I, brings her bodily alongside.

If the dock is not clear ahead and astern of the berth to be occupied, other means must be employed. The vessel may be laid abreast her berth as close in as practicable, and hauled in one end at a time by lines taken to winches. In this case, if there is no tide, the stern should be hauled in first, the bow line being slack and the bow allowed to swing out as the ship turns. This because it is always harder to haul in the stern than the bow, owing to the drag of the after body and the screw. The stern, having been hauled in somewhat, is held from swinging out by a breast line, and the bow is hauled in. The operation is then repeated if necessary, the stern being held in each time while the bow line is manned, but the bow being allowed to swing out a little each time as the stern comes in. Thus the working in of the stern is a matter of *turning* rather than of dragging in bodily, while with the bow, the reverse is the case.

If circumstances admit of going ahead somewhat, the following method is perhaps the simplest that can be employed. A spring is run from a point well forward but still abaft the center of gravity, and a breastline from a chock near the stern to a point on the dock nearly abeam (Fig. 2, Plate 118). The screw is started ahead slow with helm hard aport[1] (supposing the port side is to the dock) and the stern swings in on the spring,

1. rudder full right.



HANDLING STEAMERS AROUND A DOCK.

Fig. 1

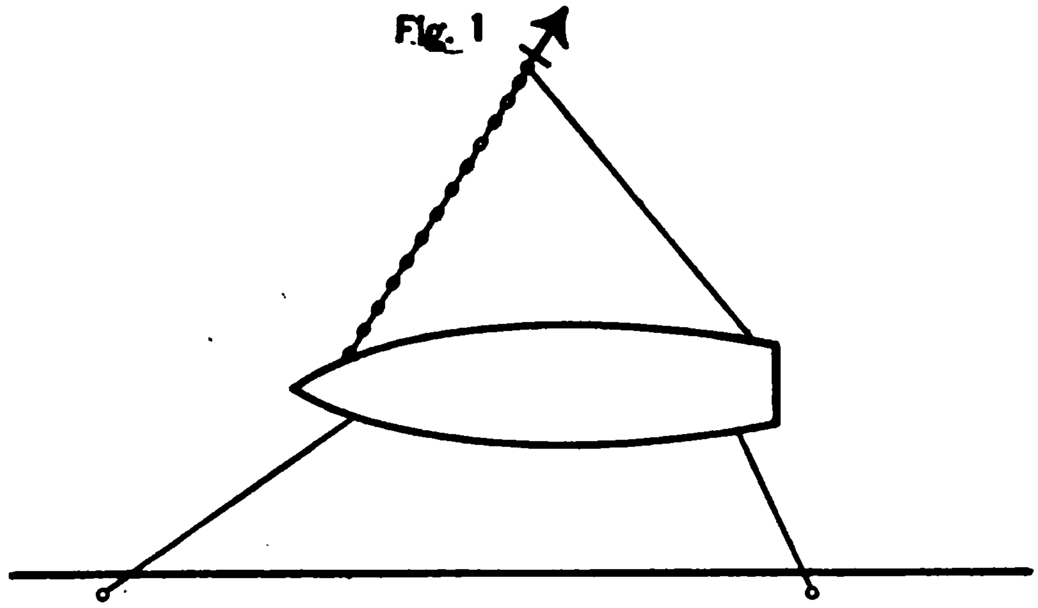


Fig. 2

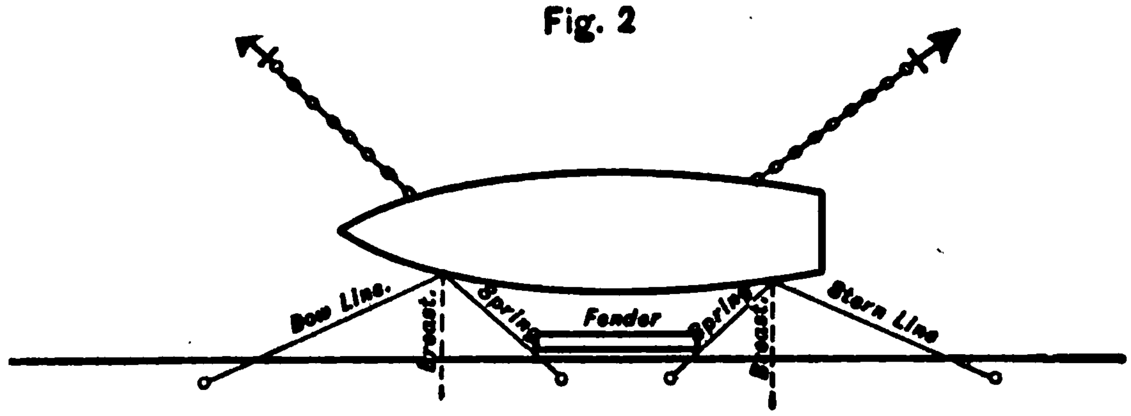


Fig. 3

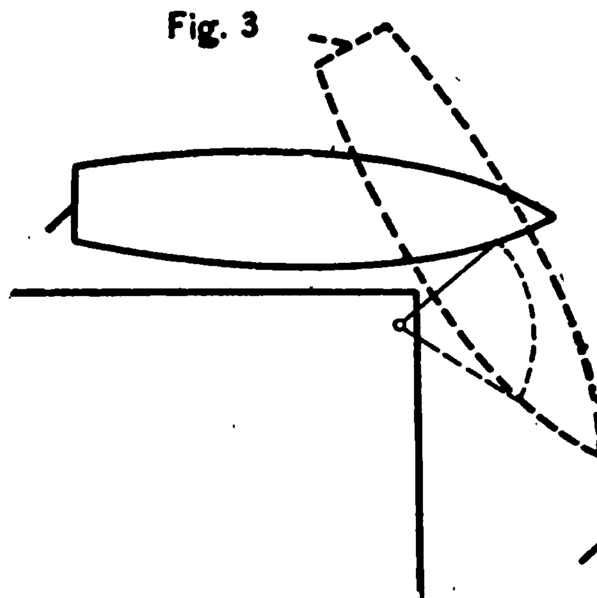
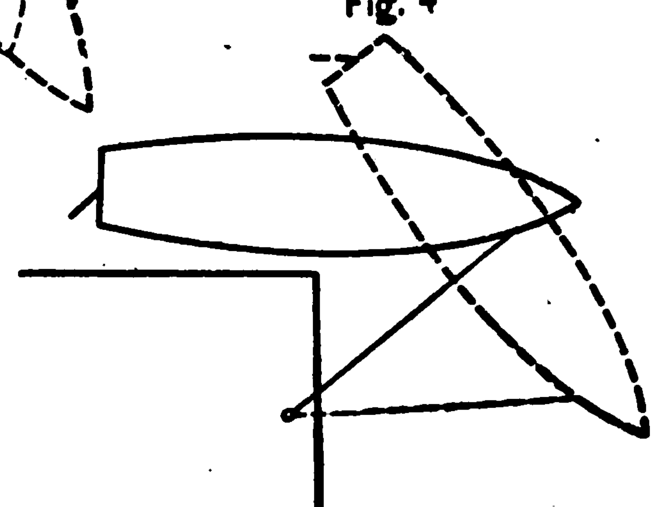


Fig. 4



HANDLING STEAMERS AROUND A DOCK

from the effect of the port helm. When she is canted as much as is thought best, the stern breast is hauled taut and held, and the helm shifted to hard a-starboard, the engines being kept ahead slow. The starboard helm now tries to drive the stern off, but the breast holds it, and, as the ship forges ahead on the spring, the bow turns in and is held by a bow breast. The helm is presently shifted to hard aport (the engines all the time going ahead) and the stern comes in again. The operation is repeated as often as may be necessary; care being taken, if a current is running, to avoid getting too much of a cant.

Still another way of working into a restricted berth is shown in Figs. 3 and 4, Plate **118.** This supposes that there is no tide. Come in at such an angle as may be necessary to clear the danger astern, putting the bow close enough to get a line ashore to some point as P, abaft the point where the bow is to be when secured. Go ahead with starboard helm,[2] which will throw the stern in, leaving the bow line slack until the stern clears the danger; then hold on the bow line, still going ahead with starboard helm. This brings her into her berth.

Under many circumstances, as for example when proposing to lie for some time at an exposed dock, an anchor should be let go outside and some distance ahead of the berth to be occupied, and the ship dropped or hauled in from this by the aid of bow and stern lines to the dock. With a head tide, a judicious use of the lines and the helm will make it possible to drop in with little or no hauling, but she must be straightened up toward the end to avoid coming in too heavily. If an anchor is needed from the quarter, this must be laid out later by a boat.

With a fresh breeze or a current setting on to the dock, it may be possible to drop in by letting go an anchor abreast of the berth with a spring from the quarter made fast to the ring (Fig. 1, Plate **119**); bow and stern lines being used as before.

Fig. 2, Plate **119,** shows a vessel secured to the face of a dock with bow and stern lines, bow and stern breasts, and with offshore moorings for holding her off.

§ III. WORKING INTO A SLIP.

Where a vessel is to be worked around into a slip, she usually makes a landing first at the outside of the pier and is then turned

2. left rudder.

either ahead or astern around the corner, swinging on a spring from near the end of the dock. It is easier to put the bow in than the stern, because of the use which may be made of the helm for steering around and into the new berth. Account must be taken of the current, and allowance made for the fact that its principal effect will be felt upon the part of the vessel which swings out into the stream—not upon the part inside the slip.

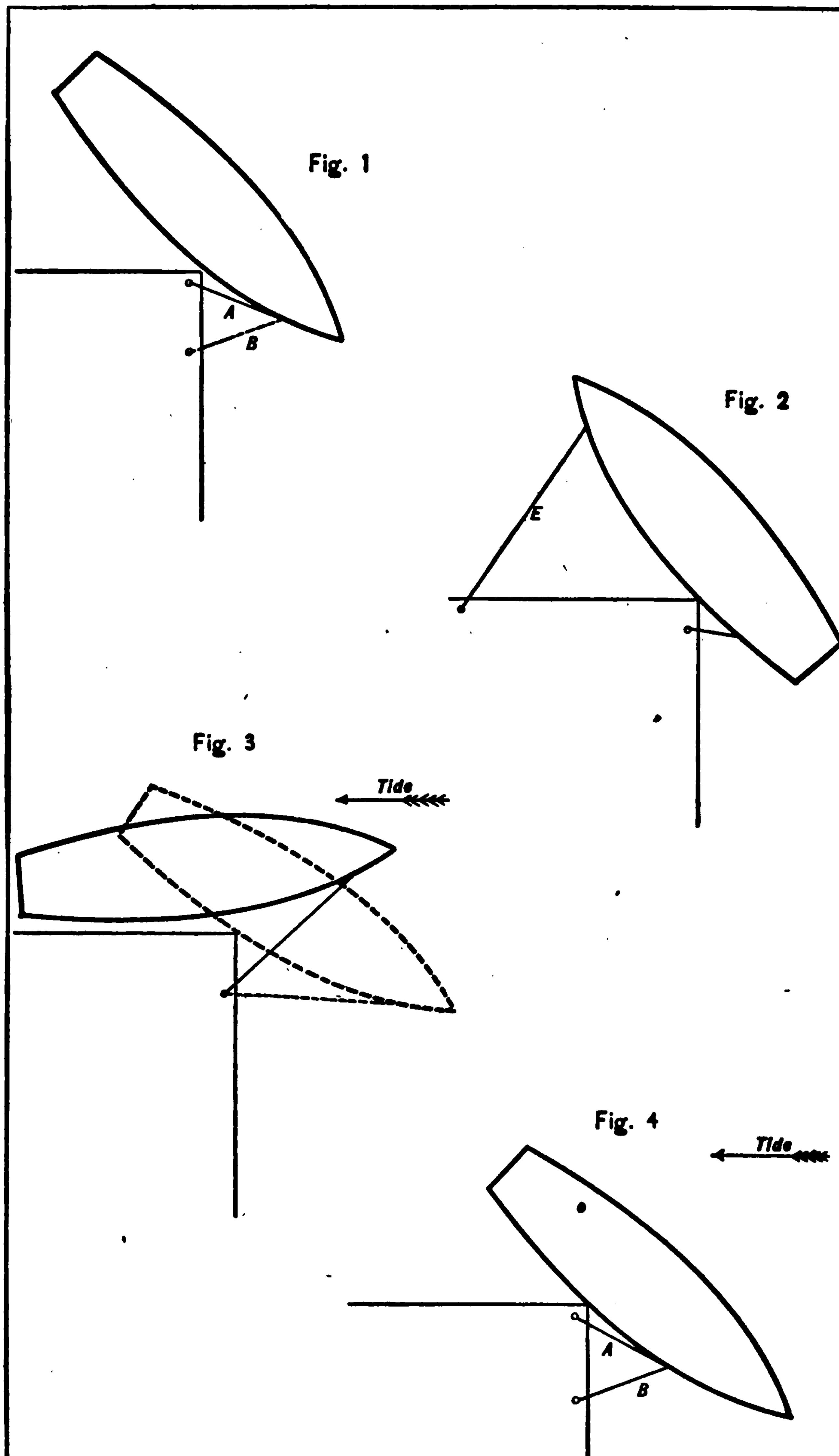
We consider first the case in which there is no current (Fig. 3, Plate 119). The vessel goes ahead sufficiently to bring her bow well beyond the end of the pier, and a line is taken from the bow to a point on the pier near the corner around which she is to turn. If the line is made fast close to the end of the pier, the tension on it is nearly a straight pull, and the turning effect is very slight. It should therefore be taken a short distance up the slip, to give a good turning effect with comparatively little strain upon the line. If, however, it is taken up too far, the ship will make a large sweep in coming around, going over to the farther end of the slip. The same effect will be produced if the bow is allowed to lap too far beyond the pier before the spring takes the strain. The effects of different conditions here may be foreseen in any given case by remembering that the point of the ship at which the line is made fast will follow the arc of a circle around the bollard on the pier.

The spring may be greatly assisted and the tension on it relieved, by making use of the helm to swing the stern out at the beginning and to steer her into place after she is pointed fairly in.

In the early part of the turn, the bow of the vessel will hug the corner of the pier, owing to the lead of the spring and the disposition of the ship to turn about her own center of gravity, throwing her stern out and her bow in. Toward the end of the turn, the same factors act to throw her off, although if rather a short spring is used, her bow will always be held in more or less closely. If it is not desired to hold her close in—because of boats or guns which might be endangered—her bow should be allowed to lap well over beyond the pier before beginning to turn, and a longer line used. The line should also be made fast farther aft on the bow, and taken farther up the slip, and the helm put hard over in the beginning. All of these points will tend to prevent binding against the corner as she turns (Fig. 4, Plate 119).

If the spring used is a short one, it will presently have a lead too nearly in line with the keel to continue its turning effect at

Plate No. 120.



HANDLING STEAMERS AROUND A DOCK.

a favorable angle, and will, if continued in use, be subject to an undue tension (A Fig. 1, Plate 120). It should be replaced before this point is reached by another line, B, having a better lead.

In making use of two lines in a case of this kind, where the lines must cross, care should be taken to keep the line which will be first let go, under the other.

A stern line is commonly used as shown at C, but in this particular case, there being no current and the vessel being under control by the helm, this line is not important.

In *backing* around into the slip, the same principles hold; but here the helm is not of much assistance, although it should be used and will help somewhat. In this case. a bow line (E) is needed to keep control (Fig. 2, Plate 120).

If there is a current, it must of course be allowed for. If proposing to work against it, as in Fig. 3, Plate 120, we must remember that the ship will be set down hard against the corner of the pier until she is fully inside the slip, and that a great deal of power will be required tc overcome the effect of the current acting against the quarter as the stern is thrown out into the stream. Here there will be an advantage in using a comparatively long spring and allowing the bow to project well beyond the pier before beginning to turn. The tendency to swing out from the pier will be counteracted by the tide. It will be especially important under these conditions to shift the spring before it leads too nearly fore and aft. A vessel held as in Fig. 4, Plate 120, for example, would probably not turn at all, while she would put a tremendous strain upon the spring. The whole situation is modified by substituting the line B for A. The vessel can now gather headway (going ahead with her engines), and work into place. The second line, (B), having been run, A is eased away until B has the strain, after which A may be shifted up the dock, and take its turn later as replacing B.

A large vessel could not be turned in this way against a strong tide without the aid of tugs to pull her stern around.

If the tide is fair, as in Fig. 1, Plate 121, the danger is that as the stern swings out into the stream it will be swept around with such force that the stern line cannot hold it. This line (technically the "swinging" line) should be a good one and carefully attended by several men. The spring should be short and taken from a chock not very far forward. It will then help to

hold her up, at the same time that it springs her around. As she swings out, the swinging line must at first be eased away roundly; but there will presently come a time when, as she moves into her berth, this line slacks up, and the slack must be gathered in rapidly to prevent her being swept down across the slip. At the same time, the spring, having done its work by pointing her fairly in, is let go, and she is steered inside, bow and stern lines being used to hold her in to the pier. These lines should be shifted frequently and used principally as *breasts*, not as springs. If her stern has swung too far over, it may be sprung in by the original swinging line or by another spring run for this purpose.

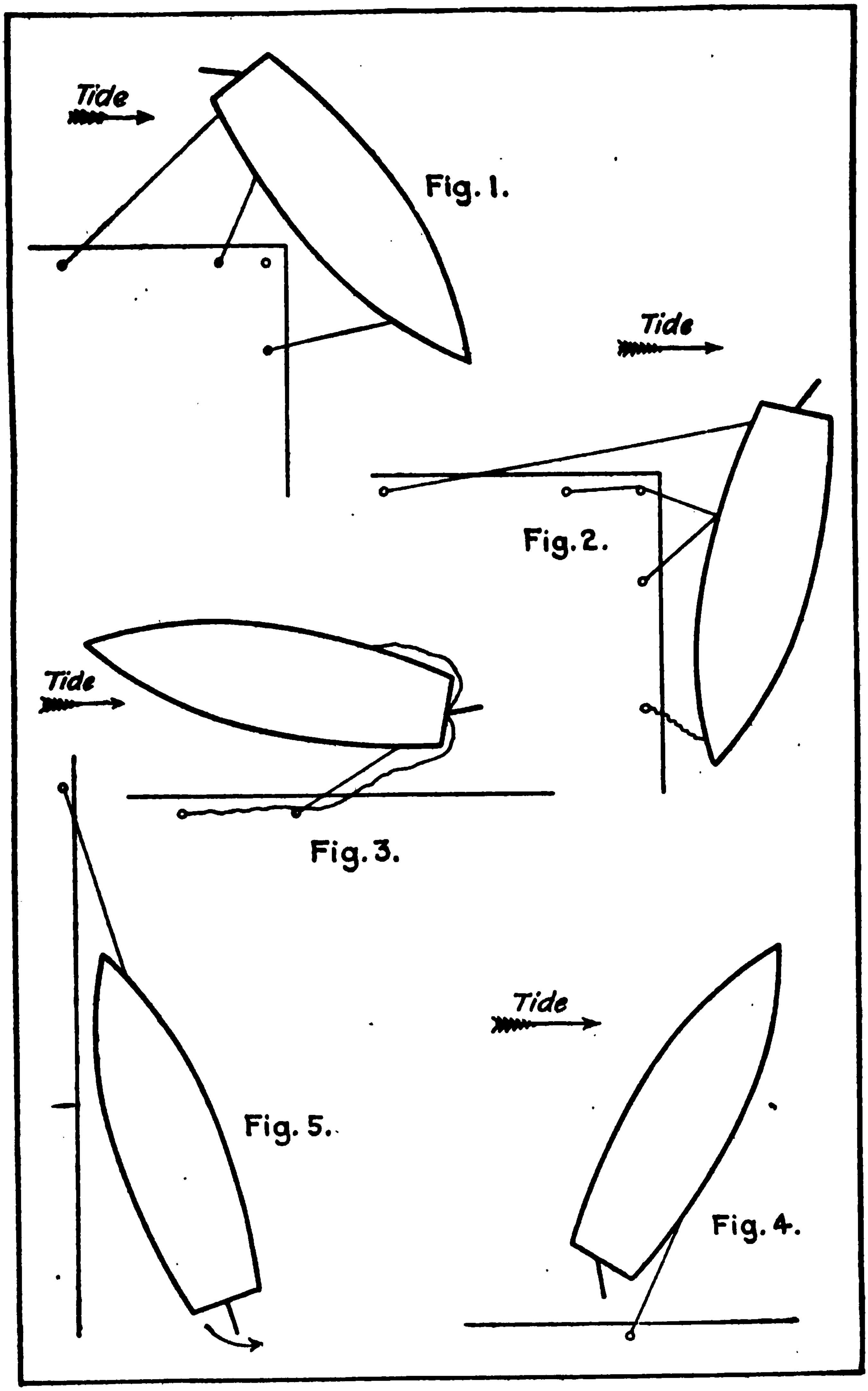
With a large ship and a strong tide, this method is not to be thought of, as the stern line would inevitably part and the stern sweep down across the slip with every probability of serious disaster.

If the ship is to be *backed* into the slip, the principles involved are the same, but the difficulties are somewhat greater because of the comparative lack of control by the helm. It should be remembered, however, that even in backing, the helm is of some value and should always be used. Even in cases where the ship is not moving through the water, the suction current of the backing screw is drawn in against the rudder, with an effect which may be utilized to more or less advantage.

For hauling into a dry dock, slack water is very important, because of the narrow space available and the exactness with which the ship must be pointed and held. A current from any direction is troublesome, but one running across is especially so

Yet if high water is essential it may be necessary to accept some inconveniences in this matter. An officer whose ship is to be docked should make himself familiar with the currents with which he will have to deal—and this none the less because the docking is usually directed by local authorities.

For hauling into the dock, the ship must be pointed fair by such means as the situation of the dock and the facilities provided may suggest. At large establishments, tugs are usually at hand for hauling the stern around. In the absence of these, lines are run from the quarter for hauling it around, while the bow is held by good lines from either side of the entrance. A line for hauling in is taken to the head of the dock, and extra lines are used wherever they may be necessary.



HANDLING STEAMERS AROUND A DOCK.

To Wind a Steamer at a Dock.

To turn a vessel end for end as she lies at the dock is a manœuvre of considerable difficulty in cases where there are no means of hauling off the bow or stern.

It may be done in a tide-way as follows: Suppose the port side is to the dock and that it is desired to put the starboard side there (Figs. 3 and 4, Plate **121**). Select a time when the tide is running feebly from ahead. Cast off all moorings but a breast forward and a spring aft. Back on the stern spring and ease away the bow breast, letting the tide catch her on the inner bow. As she cants out, let go forward and hold on to the after spring. Run a line from the *starboard* quarter fairly well forward, passing it around the stern and holding the bight up clear so that it cannot foul the screw. Make fast the other end of this line well up the dock. The tide will set her out from the dock at the same time that it swings her. As soon as the screw is clear, go ahead slow with helm aport,[1] taking care not to throw the stern in against the dock, and to keep the line from the starboard quarter clear of the screw. She will forge ahead, slacking the inner (port) spring, which may be let go and gotten out of the way. By a careful use of the helm and engines, the stern may be worked up the face of the dock but well clear of it, until abreast of the point where it is to rest when the vessel has been turned. The slack of the starboard spring is then taken in and the line made fast. As she turns, bringing the tide more and more on her broadside, she will drop down until this line holds her stern, when she will begin to swing more rapidly. As her bow turns in toward the dock, the engines may be backed if necessary to hold her stern up to its place, and even to throw it off a little from the dock if she is coming in too fast. The effect of this is to let the tide meet her a little on the inner bow as she swings in, and so to check her somewhat. It is supposed, of course, that proper fenders are in use; and here it may be remarked that in all cases of handling large steamers around docks, fenders should be used of such *length* that as the ship comes in on them, the pressure on her side will be distributed over a large number of frames, not localized at a single point.

If it becomes necessary to wind a ship when there is no tide to turn her, it may be done in much the same way as above, but

1. right rudder.

with a little more use of engines, helm, and lines. Her bow must first be canted out a little by such means as may be available. This may be by backing on a stern spring, by pivoting on a float, or by any other method which may be suggested by the conditions of the case. Care must be taken to keep the screw clear. Having canted the bow out slightly, go ahead slow, and as she moves out from the dock give her as much port helm as she will stand without swinging the stern in too far. In this way work her up along the dock, canting her out more and more. In the meantime, a line is run from the *starboard* quarter but well forward toward the midship point. This must be carefully attended to keep it clear of the screw. When she has turned out sufficiently to give this line a clear lead, it is held on and acts as a spring. Going ahead on the engines with helm hard aport[1] will now turn her head rapidly, and she may be worked around and into place without much difficulty. The fact that the spring is made fast near the midship point, gives a good leverage for the steering effect of the rudder, whichever way it is put.

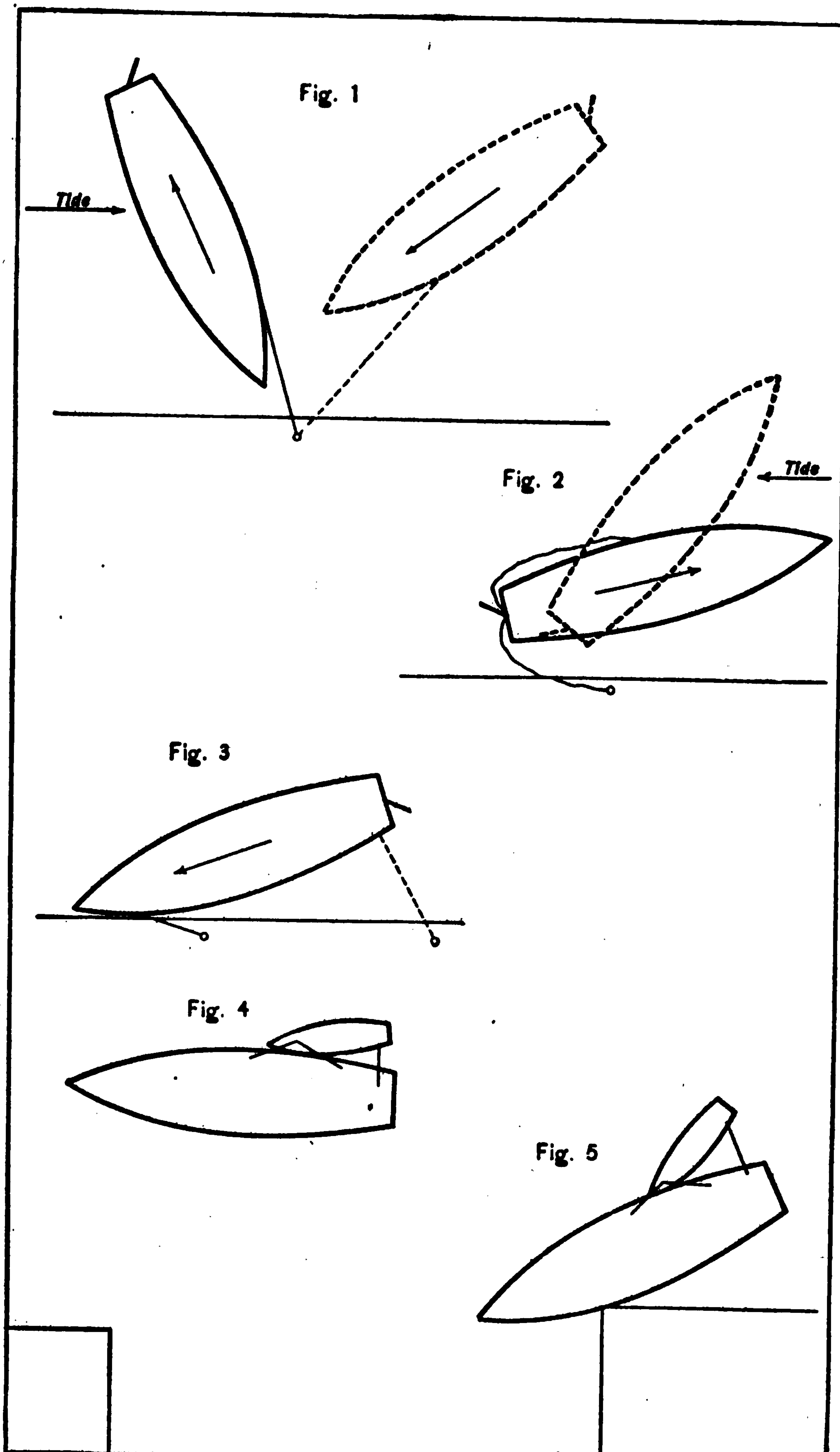
If the starboard side is to the dock and it is proposed to wind her, it may be better to back around, as the effect of the screw (right handed) will be to throw the stern out and to turn her as is desired. In this case, take a line around the bow to the port side a little forward of the midship point. Leave this slack in the beginning. Go ahead on a starboard bow spring until the stern is canted out slightly, then back with helm hard starboard,[2] holding on to the port bow line. The stern will swing around rapidly, the spring holding her up and in. When she is nearly around she may be worked in at any point desired by going ahead or backing on the engines, using the helm to steer her to her place.

It is frequently necessary to wind a vessel in making a landing. Say the tide is fair and the dock to starboard, that it is desired to put the port side in, and that there is not room to run beyond the pier and turn (Fig. 1, Plate 122). Make as much of a sweep as space permits, putting the bow in near the place where it is to be, and run a line from the port side a little forward of the midship point. Back slow with helm hard a-starboard and let her swing on the line. When she is nearly around, she may be steered into place by going ahead on the engines and using the helm.

If the tide is running out and it is desired to turn, the conditions being otherwise identical with those of the preceding case,

1. right full rudder. 2. left full rudder.

Plate No. 122.



HANDLING STEAMERS AROUND A DOCK

run up to the other end of the berth and get out a line from the port side a little abaft the midship point, taking it around the stern and keeping the bight up clear of the screw. Go ahead with starboard helm[2] and she will turn on the spring and work into place (Fig. 2, Plate 122).

It is possible to wind a small steamer by putting her stem against the dock and going ahead with helm hard over to the side which will throw the stern out and swing it around. A large steamer handled in this way would probably cut through the dock.

Freight and passenger steamers frequently have to hold their bows in against the dock for discharging cargo from the forward deck. In such cases they use a spring as in Fig. 3, Plate 122, and keep their engines turning slowly ahead with the helm hard over to the side which will throw the stern off. A steamer will lie this way for an indefinite length of time even though the tide may be ahead. If the tide is aft, a stern line is used to assist in holding her.

GETTING CLEAR OF A DOCK.

In preparing to get clear of the dock, all lines should be singled, and as many as can be spared got out of the way; all permanent fasts let go and hauled to the dock, spur-shores cleared away, and men stationed by the line which will be the last cast off.

It is convenient to select a time when a feeble current is running along the face of the dock, to set the bow or stern out (the line at the other end being kept fast), thus getting a cant for working out, either ahead or astern. In the absence of such a current, advantage may be taken of a breeze setting off from the dock, or the bow may be swung in more or less by going ahead slow on a bow line with helm hard over to the off-shore side. She may then be backed off clear.

Care should be taken in all cases, but especially with twin-screws, to keep the screw clear of the dock.

With a current or a fresh breeze setting onto the dock, it will be necessary to provide some means of hauling out, and for this purpose a tug is most convenient, unless it happens that a line

2. left rudder.

can be run to a buoy or to a neighboring dock. If an anchor has been dropped in coming alongside, it will of course be useful now. In the absence of any other means, a stream anchor may be laid out without much trouble.

It is sometimes necessary to get clear of a dock where the current always runs strongly in one direction, as in a river. Officers having this to do as a part of their regular business become very expert at it. A case in point is the Peiho River, at Tientsin. The river is only just wide enough for the steamers trading there to swing from shore to shore, and the tide runs four or five knots and never slacks. Steamers lie alongside with head up stream, port side to dock, and when ready to turn for going out, having a full head of steam, they cast off all but a line from the starboard (off-shore) quarter, and swing out into the stream. The bow sweeps around with great rapidity athwart the current, and down the stream. At just the right instant, while heading three or four points across and down, the starboard quarter line is cast off and the engines started full speed ahead with helm hard over.

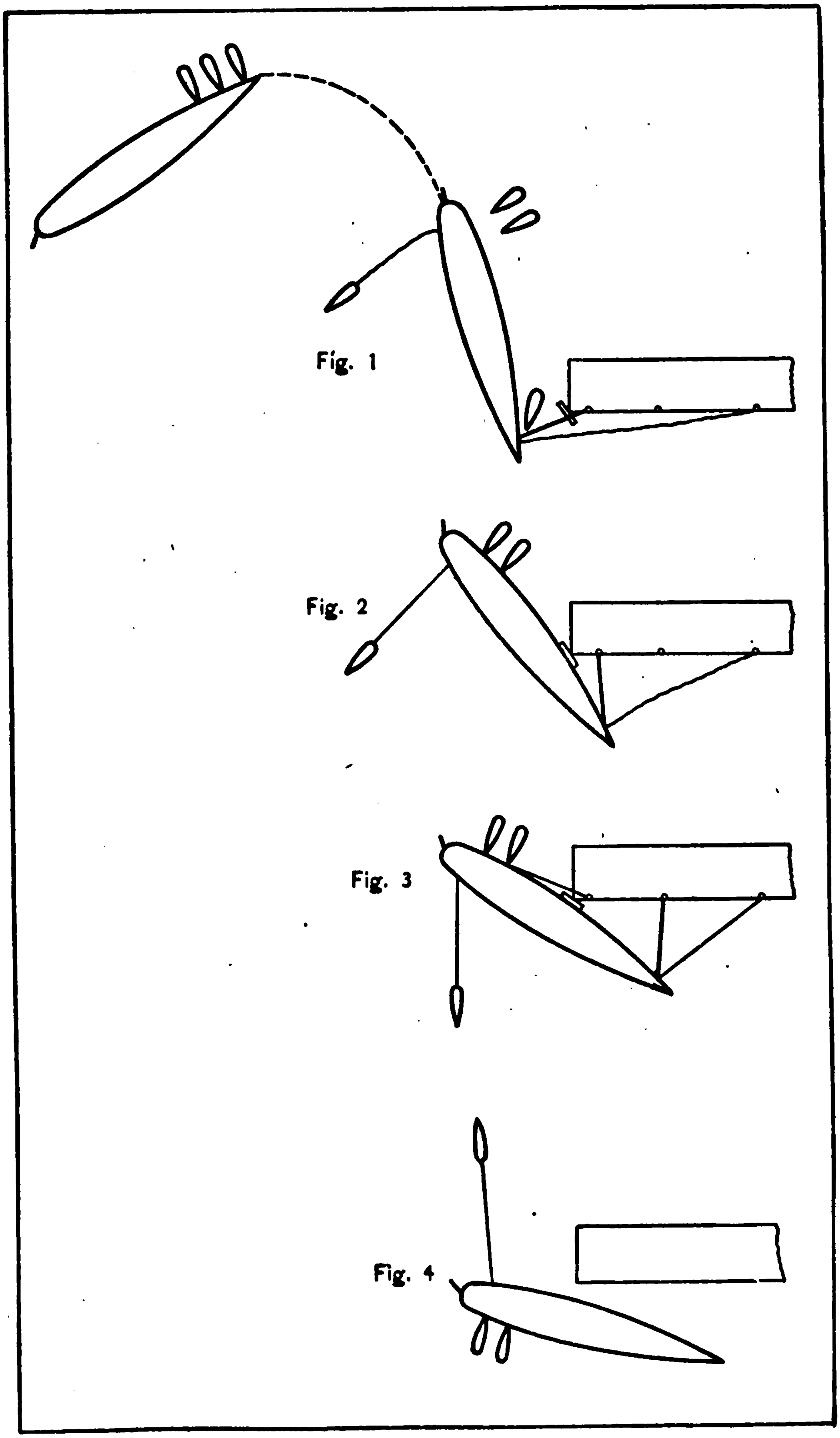
§ IV. HANDLING A LARGE VESSEL WITH THE AID OF TUGS.

In some cases tugs are used for actually towing the larger vessels; in others, merely for turning them, holding them up against the tide, etc.

A tug having to tow a large vessel in docking is usually placed on the quarter which will be away from the dock, with a line for going ahead and another for backing, both of which are taken from the *bow* of the tug to some convenient point on the other vessel. A breast line is also run from the stern of the tug to prevent her from swinging off (Figs. 4 and 5, Plate 122). A tug placed like this is favorably situated for turning to either side by going ahead or backing.

In some cases it is found convenient to place a tug on the off-shore bow. This is in case the vessel must be brought to the pier with a considerable cant inward. The tug on the bow is well placed for bringing her in like this and for hauling the bow out at the last moment while the stern is being worked in.

In docking large ocean liners, a number of tugs (frequently as many as six) are used for turning the vessels and for holding



DOCKING A LARGE STEAMER.

them against the tide as they work into their slips; but such headway or sternway as is needed is generally given by the engines of the vessels themselves.

In this, as in all other cases of working around a dock, much use is made of the helm; and if the vessel has twin-screws, these are used also, in connection with the tugs, for turning her.

The tugs may take lines from the bow or quarter, or they may point their stem-fenders against the side, and push. Spring and check lines are used as in the cases already described, but are not trusted to the same extent for checking the vessel or for springing her around. They must be large and very carefully attended. If allowed to lead fore and aft or nearly so, they will almost inevitably carry away as the ship forges ahead upon them. They should therefore be frequently shifted as she moves along the dock, being kept approximately at right angles to the side.

The following description of berthing a large Atlantic liner on the New York side of the North River is contributed by an officer of many years' experience in such work. As the tide is running flood (to the northward) the ship is berthed on the south side of the pier (see Plate 123).

> On the flood tide, the ship comes up the river on the Jersey side and is turned completely around, above the pier, by the aid of tugs which are placed with their fenders against the port bow (Fig. 1, Plate 123). After the ship is turned nearly parallel with the tide or with the trend of the river, one tug is usually kept alongside on the port bow, in case the ship's head should require to be canted to starboard, the other tugs backing away ready to be placed on the port quarter. As soon as the ship is near enough to her pier, heaving lines are sent off to her by a small rowboat and by means of these the bow-lines are run. These lines are led some distance up the slip. Another heaving line is carried to the ship and a hauling line of about 3" manila is sent from the ship to the pier, where it is made fast with a long bowline through the eye of an 11" manila hawser which is faked on the end of the pier, near the southeast corner. When ready, the 3" rope is taken through a forward pipe to one of the ship's winches, the hawser hove on board and the eye hove over the bitts. This line is for helping to slew her around into the slip. The ship is then allowed to go as far ahead as possible before the strain is permitted to come on the spring (Fig. 2, Plate 122). Great care must be taken that the ship does not get too much of a cant towards the pier, with the tide too broad on the starboard bow, as it is most important that these heavy vessels should not be permitted to approach the corner of the pier sideways at any great rate of speed, but gradually. We have had instances of ships taking the corner of the pier

with apparently only a moderate force and denting plates and bending frames to such a degree that it was a question of thousands of dollars to place the hull of the ship in its original condition. We use for a fender a spruce built log, about 40 feet long by 30" by 24". This log is fitted with chains and ropes so that it can be handled from the pier and placed in any position required. It is laid across the corner of the pier for the ship to land on at the water line, so that instead of one or two of the ship's frames taking the pier, she is landed on a dozen or more. As soon as the ship takes the fender, signal is given to the tugs and they commence to push her port quarter out into the stream. One tug is usually placed on the starboard quarter attached to a hawser, while two or more push on the port quarter. With a twin-screw ship it is necessary to have at least this one tug on the starboard quarter to prevent her quarter from taking the corner of the pier with a flood tide running, endangering fouling the port propeller. The bow ropes by this time are passed some 150 or 200 feet up the pier. When all is ready, the signal is given to the bridge, starboard engine "Slow Ahead," helm starboard.[2] The ship gradually swings towards a line at right angles with the trend of the river with her bow pointing into the slip. As she comes around, the *check* is slacked away to permit her to go ahead, and bow-lines are shifted as required (Fig. 3, Plate 123).

The after ropes are run by the small rowboats, sometimes by tugs, as soon as her quarter nears the end of the pier. As she moves into her berth, the bow and stern lines are kept as nearly abreast as possible, by short fleets, and the ship's stern kept as close to the pier as is prudent, always taking into consideration the care that must be observed not to foul the port propeller. The engines can move the ship ahead or astern as much as necessary. There is a 12" check rope on the pier near the berth, ready to be hauled on board into one of the after chocks on the lower deck. There is also a wire pennant passed out from one of the chocks from the lower or spar deck, with an eye, in which is to be hooked the block of a threefold purchase block leading from the pier.

When she has sufficient way to reach her berth, she is placed in proper position by lines and tackles which are entirely in the hands of the shore gang on the pier.

The warps used on these vessels are 7" and 8". The lines themselves must never be passed forward from the stern chocks, but heaving lines used when it is necessary to pass forward any distance away from the quarter, as great care must be taken that these warps are not allowed to foul the propellers. In handling the check from the end of the pier, the shore end should be fleeted as often as possible as the ship goes ahead, in order that the strain may not be brought too much fore and aft. Of course the nearer the check is kept at right angles with the line of the ship, the less strain will be required on it to cant the ship's head, and when it is nearly fore and aft almost the slightest way on the ship will carry it away, unless the greatest care is observed.

2. left rudder.

Leaving the Slip.

We undock these ships from both north and south side of the pier at any stage of tide.

When undocking from south side of the pier, with tide running strong ebb, an 11" line is taken from the port quarter to one of the largest tugs (Fig. 4, Plate 123). Extra men are placed on the tug to assist in handling this rope. Two or three moments before the sailing time, the tug starts ahead to the northward and pays out perhaps 75 or 80 fathoms of scope. As the stern of the ship is about 100 feet inside the end of the pier, this hawser is rove through a thimble spliced into a 4 tail rope. This slip rope is taken around the post at the south corner of the pier with three or four turns, and the end held by some of the shore gang, to prevent the bight of the hawser from flying into the crowd that is usually on the dock at sailing time. When the ship is far enough astern for the bight of the hawser to clear the corner of the pier, the slip rope is let go. The end of the hawser attached to the ship is fitted with a lashing eye (old cargo falls are used for the lashings) and the eye hove over one of the bitts. When the ship is turned head to the southward, this lashing, at a signal from the bridge, is cut on the ship; the eye of course flies clear of the vessel and prevents any danger of fouling the propeller. In addition, one or two tugs are used to push on the starboard quarter. As soon as the ship is partly out of the slip these tugs let go the quarter and proceed to the port bow. With the aid of the tugs on the port bow and the one attached to the hawser, the ship of course is swung with her head to the southward, and when far enough around the tugs are let go and ship proceeds.

With the flood tide, two or three tugs are ready to put their stems against the port quarter of the ship. As soon as the propeller is well clear of the pier these tugs are to ease the ship off the corner as much as possible. For sliding out we have a built spar, 50 or 60 feet long by 20" by 24". This spar is slung abreast of a plate on the ship's side that is clear of sidelights and coal ports, and is secured firmly to the pier by chains and heavy ropes. The outer side of the spar is sheathed with 2" spruce that can be easily replaced as it becomes broken or splintered.

For handling a large liner when her own engines are not available, at least six tugs would be used; one on each bow (ahead) one on each quarter alongside and one on each quarter with a single line. The tugs alongside are especially for stopping the vessel's way when necessary, though of course they assist also in moving her ahead and in turning.

Turning a Vessel While Towing Alongside.

A tug towing a vessel alongside sometimes has occasion to "*wind*" the tow for putting her alongside in a particular way, or for getting on the off side in landing, to avoid being jammed between the tow and the dock. Plate 117.

The tug first gives the tow a sheer with the helm (Fig. 3). She then backs, slacking all lines except the backing line (Fig. 4), then, a little later, slacks everything and puts her stem against the stern of the tow and goes ahead, pushing the stern around (Fig. 5); and ends by making fast alongside with her bow toward the stern of the tow (Fig. 6), and with her own port side to the tow instead of the starboard side as in the beginning. This manœuvre may be seen every day in New York harbor, where tugs handling scows have to get on the *off side* of the scows for landing the scows alongside while themselves keeping clear.

CHAPTER XVI.

PLACING A SHIP IN DRY DOCK.

The operation of safely placing a ship in dry dock, safely supporting her with blocks and shores, and afterwards floating her out of dock, is so common that the care and experience necessary to ensure success in this operation are not generally understood, yet it is possible that very serious damage may occur during the operation, if intelligent supervision be neglected.

Every ship should carry a docking plan which shows: the length on the load water line; the length over all; the location of all the under water valves; the locations of the water-tight bulkheads, the engines, the boilers, the turrets (if any), and such other weights and fittings as are peculiar to any particular ship; the length cf straight keel, together with dimensions locating accurately the cut-up (if any) of the dead wood aft, together with any peculiarities of the stern post and rudder; also such dimensions as will show the curvature of the forefoot, especial care being taken to locate the exact point where this curvature departs from the straight line of the keel. The docking plan of a battleship is shown on Plate **124**. The docking plan should also contain information as to cross-sections amidships and elsewhere, showing the beam at or near the water-line, the shape and location of the keel, the docking keels and bilge keels, the struts, the propellers and all other objects below the water-line; in other words, the docking plan must furnish all necessary information concerning the under-water hull and its accessories, also dimensions as to projections above the water-line which increase the nominal beam of the vessel: the latter information is frequently of extreme value in foreign ports whose docks have their dimensions tabulated with reference to merchant vessels only.

In our navy yards, blue-prints of such plans are usually in the possession of the Naval Constructor—elsewhere it is necessary to furnish such plans to the responsible authorities of public or private docks—without them, the efficiency and safety of the docking are absolutely dependent upon the skill and experience of those having control of the docks.

The dock master of any particular dock being given the docking plan of a ship to be placed therein, proceeds as follows: knowing the ship's draught, the maximum depth over the sill, together with the current and tidal variations in the vicinity, he decides upon the time the vessel should enter the dock, and so informs the commanding officer, who thereupon makes the necessary arrangements to ensure that the vessel at the time specified shall be absolutely upright, without any list either to starboard or port.

The entrance to a dry dock may be closed by hinged gates, a floating caisson, or a sliding caisson; the first and last methods are often used in foreign docks, but in home docks, a floating caisson is most commonly found; it usually has a ship-shape form with sufficient stability to safely float upright when empty; to sink it, valves are opened which admit water to its interior, and to raise it, all outboard valves are closed and the water it contains is pumped overboard.

The dock floor carries along its center a line of blocks, called "keel blocks." These are usually of wood and are secured to the dock floor in various ways. Their distance apart varies in different docks, but it is customary to place these keel blocks much closer together under turrets and other heavy local weights on war ships, than is done with ordinary vessels. Those ships having straight keels, but whose fore-foot is cut away, are supported forward by building up the corresponding keel blocks to suit the contour shown on the docking plan. With ships having docking keels, a double line of keel blocks is provided, running parallel to the center line and at the proper distance therefrom, given on the docking plan. At intervals along the bottom of the dock and at right angles to the center line, are the bilge ways, along which slide the bilge blocks which can be moved towards or away from the center line by the hauling lines which are manipulated from the dock coping. Each bilge block is built up of a proper height and level, as determined from the docking plan, so that after the vessel's keel rests upon the keel blocks, the bilge blocks can be hauled and accurately fit against the bottom, thus thoroughly supporting the ship before the water has been pumped out of the dock. Care is taken that the bilge blocks are not hauled so that they will bear against an under-water valve or other accessory which would be injured by heavy local pressure. In foreign docks, bilge blocks are rarely used, shores being fitted to sustain the bottom after the dock is empty.

To maintain the vessel upright after she has grounded on the keel blocks, and before the bilge blocks are hauled, wale shores are used, one end resting against the ship's side, the other against the dock's side, wedges being used to set them taut. These shores are prepared of the desired length and placed in the vicinity of their final location by means of information obtained from the docking plan. Certain marks are also made on the coping which will accurately locate the ship's position in the dock, in order to ensure that as the water is pumped out, the under-water hull shall exactly coincide at the proper time with the various blocks and shores which have been made ready to receive it. Plate **124** shows the plan which would be prepared for a particular dock after receiving the docking plan of the vessel which was to be placed therein.

These preparations being completed, water is admitted, the caisson is floated and removed, and the dock is then ready to receive the ship. After the ship's bow has safely entered the mouth of the dock, the responsibility for her safety rests upon the dock master; the methods of securing this safe entrance are considered elsewhere. The dock master then hauls the ship into the dock until certain definite objects near her bow and stern coincide with the marks which he has laid out upon the dock coping in accordance with the docking plan. The caisson is then placed in position, the pumps which empty the dock are started; their operation between this time and the time of the complete emptying of the dock being controlled by the judgment of the dock master.

In the meantime the necessary arrangements have been made to ensure the ship being safely centered in the fore and aft and athwartship directions, and the wale shores have been floated and placed approximately in their proper positions: during this period, by the use of sighting battens or other means, the variations of the ship from the upright are finally determined, and the necessary measures are taken to correct any listing to starboard or to port.

Under ordinary circumstances, the ship's keel first touches on the keel blocks aft, and with a ship having a large amount of drag, special precautions are necessary to prevent listing, because, under these circumstances, stability is lessened very rapidly. The grounding of the keel aft upon the keel blocks is indicated in various ways, but before this occurs, the dock master has ar-

ranged the wale shores so that any inclination towards listing or twisting shall be prevented as far as possible. The entire line of wale shores is not set up tightly until the forward portion of the keel is bearing upon the keel blocks prepared to receive it. As the water level within the dock becomes still lower, the bilge blocks are hauled, and the ship during the remaining period of her stay in dock is supported by the keel blocks, bilge blocks, and shores.

After the dock is emptied, the ship's bottom is thoroughly cleaned and careful examination is made of the entire bottom as regards fouling, corrosion and damage. All outboard valves, propeller struts, propellers, shaft bearings, rudder pintals and gudgeons, strake edges, butts, etc., are carefully examined. It is usually necessary to re-grind the underwater valves, and to re-pack the stuffing boxes of valves and of the rudder; if the plating butts show lines of rust, they should be re-calked; if the rivet heads show serious corrosion, the rivets should be removed and new ones driven; if there is serious corrosion or pitting, the plating should be thoroughly cleaned and brushed before re-painting; in cleaning the bottom from fouling substances, care should be taken that the paint underneath is disturbed as little as possible; zinc rings and zinc plates at the openings of outboard valves, and in the vicinity of the propellers, should be renewed if their corrosion shows galvanic action. The bottom is then given fresh coats of anti-corrosive and anti-fouling compositions, which should be applied whenever possible, on dry surfaces.

If special repairs have been anticipated or are found to be necessary after the dock is empty, the necessary action is taken immediately, because the length of time a ship remains in dock must be reduced to the minimum.

The particular precautions which must be taken in docking ships which are not in ordinary condition, must depend upon the judgment of the dock master.

During the period that a ship is in dock, no change of any kind in the distribution of her weights should be made without the knowledge and consent of the dock master, because the ship when being floated might suddenly change her trim so as to cause serious damage to herself or to the dock.

The painting of the bottom, and all under-water repairs being completed, a time for flooding the dock is agreed upon by the commanding officer and the dock master. The former stations

men at the outboard valves and elsewhere, as he deems proper to ensure that water does not enter the ship, and the latter stations men at the various shores and lines and elsewhere, to prevent as far as possible, any injury to dock or ship, from a change of weights or an unexpected alteration in tide or wind.

The water in the dock enters continuously under the dock master's control. When it has risen to a sufficient height, the bow ordinarily first lifts from the keel blocks, and shortly afterwards the stern. If there has been any material change of weights while the ship has been in dock, she will suddenly and violently take a list to starboard or to port, with consequent damage to herself and the dock.

The ship being safely afloat, the water is allowed free entrance until the level within the dock coincides with that outside, after which time the caisson is floated as quickly as possible, then removed, and the ship is floated out of dock.

CHAPTER XVII.

WEATHER AND THE LAWS OF STORMS.

§ I. WEATHER, WINDS, CLOUDS, RAINFALL.

The subject of weather may conveniently be studied in its general features by reference to a map showing normal or average conditions at different seasons of the year. Plate **125** gives such a map, showing normal winds, barometer pressures, and temperatures, for January and July, throughout the world with the exception of the extreme polar regions. The curves in black are "isobars" or lines of equal barometric pressure. It will be seen that these lines are, in the main, closed curves about areas of high or low barometer;—the distinction between a "High" and a "Low," as these areas are called, depending not upon the actual height of the barometer, but upon the way in which the wind circulates about the area; or, more accurately, upon whether the characteristic pressure is the result of descending or of ascending currents. It is clear that a high pressure is the natural accompaniment of descending currents of heavy air, and vice-versa; but whereas a barometric height of 30 inches may indicate a rising current at one place and time—which would make it a Low;—it may indicate a descending current at another place and time, and may thus be a High. It tends to clearness, therefore, to use, instead of "high" and "low," the terms "anti-cyclone" and "cyclone," which define the wind circulation instead of the pressure resulting from this circulation. As thus used, the term cyclone has no necessary connection with a gale. It defines simply a condition of affairs in which an ascending current of air at a more or less clearly marked central area is surrounded by an inflowing spiral whirl which may or may not take on the concentrated and intense character with which we commonly associate the term cyclone. Similarly "anti-cyclone" defines a condition of affairs in which a descending current of air develops into an outward flowing spiral whirl with a motion of rotation opposed to that of the cyclone (Plate **126**). Both of these phenomena will be more fully described hereafter.

The relative positions of the warm red and cold blue tints

Plate I

WINDS AND WEATHER

No. 125.

FOR JANUARY AND JULY.

(Following page 471)

on Plate **125** show January as winter in the northern and summer in the southern hemisphere; and July as summer in the northern and winter in the southern hemisphere. The bounding lines of the red and blue tints are the isotherms (lines of equal temperature) of 70° F. and 30° F. respectively. It will be noted that the thermal equator—as the middle of the equatorial hot belt may be called—does not coincide with the geographical equator, but fluctuates in a way which is evidently influenced by the seasons, continents, oceans, and winds.

When air is heated, it expands and becomes lighter; it therefore rises, and the ascending currents cause a decrease of pressure. Another important result follows in the formation of clouds and rain due to the presence of aqueous vapor in the ascending current. As the air rises it expands more and more, cooling at the same time through the absorption of heat due to this expansion, while it is still further chilled by the lower temperature of the upper regions of the atmosphere. As a consequence of the reduction in temperature, much of the aqueous vapor is condensed into clouds or precipitated in rain, giving off a large amount of heat, which tends to rarefy the air still further and so to intensify the upward draft.

We have here, briefly outlined, an explanation of the weather characteristics, which in some degree mark all regions of low barometer and cyclonic circulation, whether these extend over thousands of miles of ocean and continent as in the cases shown on Plate **125**, or are localized in the narrower and more intense form of tropical hurricanes. The weather of all such regions is characterized by more or less cloudiness, frequently accompanied by rain, by low barometer, and by winds which, while not necessarily violent, are usually stronger than in an anti-cyclone, since the determining cause of these winds—an upward rush of warm air with the attendant features that have been described—naturally takes on a somewhat more violent form than does the downward current of cool and heavy air which is the determining cause of anti-cyclonic circulation.

The velocity of the wind, as well as its direction, depends upon relative pressures in adjoining areas; being determined by the steepness of the "barometric gradient," or the amount of difference in the reading of the barometer for a given distance. This is well illustrated in the cyclone and anti-cyclone of Plate **126**, in which the distance between the successive iso-

bars indicates the steepness of the barometric gradient. Where the isobars are crowded closely together, the change in pressure is very great for a small change in position; or in other words the gradient is very steep. At such places the velocity of the wind is high. Where the isobars are separated more widely, they indicate a gradual change in pressure or a gradual slope to the gradient, and here the winds are more moderate.

To compare barometric gradients, they are commonly reduced to hundredths-of-an-inch per 15 sea miles. On this scale the steepest gradient ever observed was in the cyclone that passed over False Point, India, in September, 1885. This gradient was 238; which means that in a distance of 15 miles, there existed a difference in barometric reading of $2\frac{38}{100}$ inches.

It will be observed in Plate **126**, that the wind blows partly across and partly along the isobars, forming the spiral whirl which has been elsewhere described.

The following description and explanation of a sudden shift of wind over the North Atlantic Ocean is from the Pilot Chart of the U. S. Hydrographic Office for July, 1900 (Plate **127**).

It illustrates in a very striking way the relation between the direction of the wind and the barometric pressure.

During the course of March 17, 18 and 19 last, the steamers along that portion of the transatlantic routes lying to the eastward of the meridian of 60° experienced a sudden shift of the wind from S.E. to N.W., accompanied by a marked increase in force, as indicated by the following table. The shift progressed steadily eastward, the date and hour at which it was noted aboard the several steamers distributed along the lane depending upon the position of the various vessels at the time, becoming successively later as the longitude diminished.

Vessel.	Date.	Long., West.	REMARKS.
Nederland..	Mar. 17	61° 35'	Strong to fresh breeze (from the South); at 8 a. m. wind shifted suddenly to NW.
Maryland...	Mar. 17	57 42	Southerly wind until midnight, when wind veered to NW. strong.
Minnesota..	Mar. 17	56 29	Southerly wind shifting at midnight to NW.; moderate gale.
Turcoman..	Mar. 18	51 27	At 3 p. m. wind shifted suddenly from South to N NW. and blew a moderate gale.
Anchoria...	Mar. 18	50 42	Wind SE.; at 5 p. m. wind hauled to W SW., later to NW.
Chester.....	Mar. 18	48 53	At 11 p. m. wind shifted (from S SE.) to NW., moderate gale.
Mokta.......	Mar. 19	48 22	At 2 a. m. wind shifted from S SE. to N NW.
Hekla	Mar. 19	46 47	Wind S SE., 2, until 5 a. m., when it shifted through SW., West, to NW., 8.
British King	Mar. 19	46 00	At 8 a. m. wind shifted from SE. to NW.
Euxinia.....	Mar. 19	44 52	At noon wind suddenly shifted from SE. 5, to N NW., 6.
Symra	Mar. 19	44 04	Wind from South; at 1 p. m. wind changed to W NW.
Helios	Mar. 19	42 10	At 8 p. m. wind changed (from SE.) to N NW.

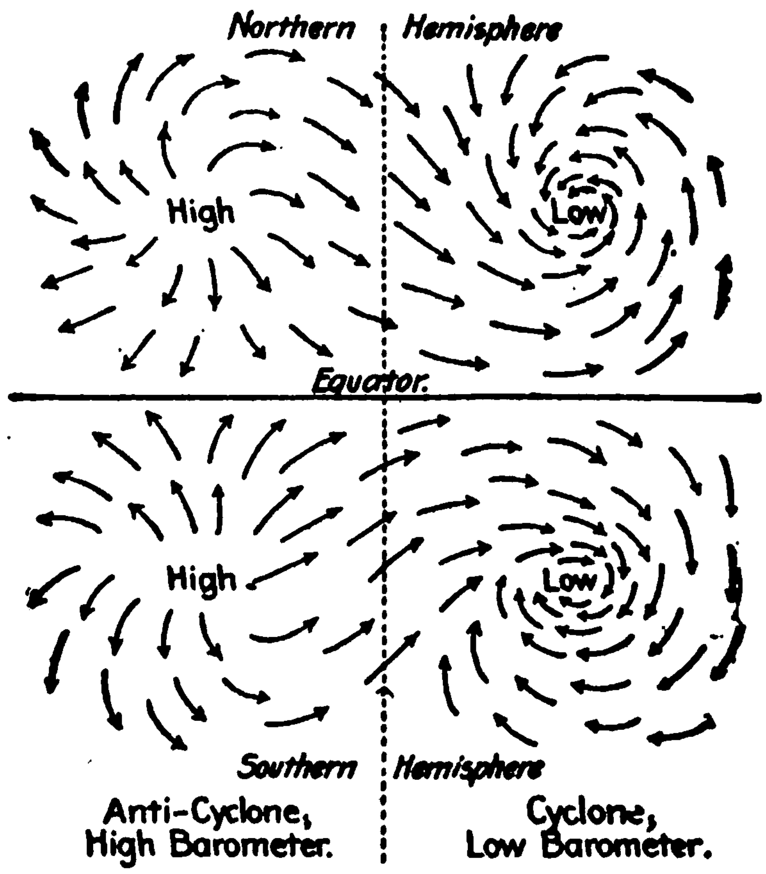


FIG. 1. CHARACTERISTIC WIND CIRCULATION ABOUT CENTERS OF HIGH AND LOW BAROMETER IN EACH HEMISPHERE.

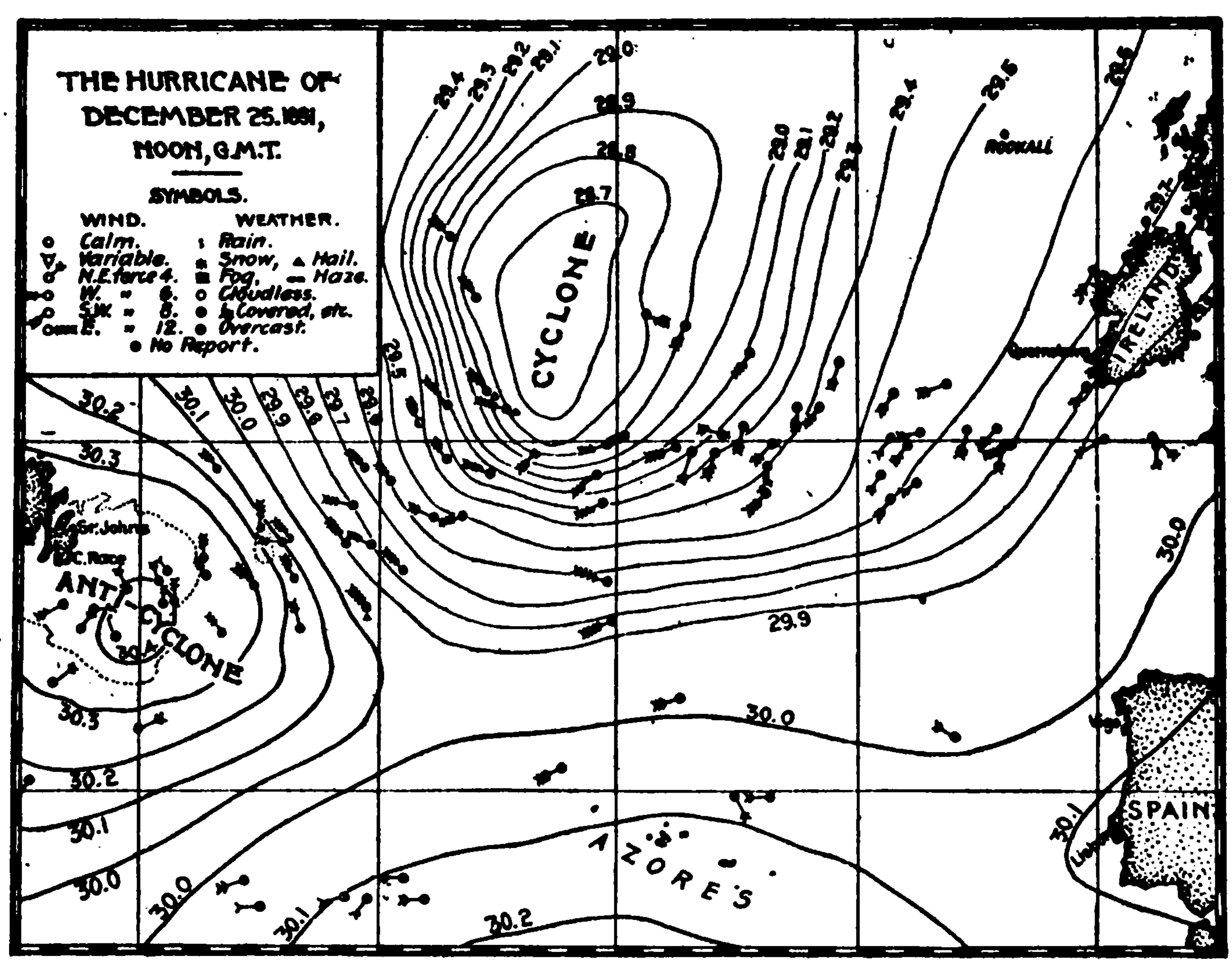


FIG. 2.
CYCLONE AND ANTI-CYCLONE IN THE NORTH ATLANTIC.

Plate No. 127.

Fig. 1 Barometric Conditions over the North Atlantic, causing a Sudden Shift of Wind.

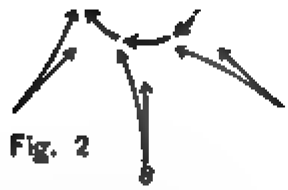


Fig. 2

Air flowing toward a "Low" and Diverging according to Ferrel's Law to form a Cyclonic Whirl.

Fig. 3

From "Storms, Storm-tracks and Weather Forecasting" Published by the U. S. Weather Bureau.

Storm Tracks for August.

The Storms noted during 10 years are grouped according to their places of origin, the figures opposite the brackets indicating the number for each group.

STORMS AND STORM TRACKS.

The meteorological conditions prevailing throughout this part of the North Atlantic at Greenwich mean noon of March 19 are shown upon the chart (Plate 127), where the symbols have the usual significance—the center of the arrow head marking the position of the observing vessel at the time of observation, the arrows flying with the wind, the number of feathers indicating the force of the wind, etc., etc. An inspection of the chart shows that the sudden shift of the wind (which several observers in their extended remarks stated was not announced by any decisive variation of the barometer, the mercury standing above 30 inches throughout) was due to the passage of the observing vessel across the shallow trough of low pressure which intervened between the two areas of high, each of these latter areas being surrounded by a well-developed system of anti-cyclonic winds, the light southerly and southeasterly winds proper to the rear of the preceding area being almost instantaneously supplanted by the strong northerly and northwesterly winds proper to the front of the following area. For the purpose of distinctness the outline of the trough is indicated by cross-hatching.

The several heavy dotted lines join the points at which the shift occurred at the same hour, the latter being indicated in the diagram. Thus along the entire length of the most western of these lines the shift was noted at 8.00 A. M. of March 18; along the next at 8.00 P. M. of March 18, and similarly for the others. Comparing the distance intervening between these lines it is seen to be in the neighborhood of three degrees of latitude or 180 nautical miles, giving for the eastward progress of the shift an average velocity of 15 miles per hour.

The indrawing air of the cyclone obtains its moisture by evaporation from the sea and from damp earth, or from areas of ice and snow if it passes over such. Its capacity for holding moisture in invisible suspension increases with the temperature; and for a given quantity of moisture so held, there is a perfectly definite temperature, called the "saturation point" or "dew point," below which the air cannot be cooled without giving out some part of its moisture in the form of cloud or rain. As already explained, this is why the warm moist currents from the surface of the earth, as they rise into the cooler regions of the upper atmosphere, produce the clouds and rainfall of cyclonic weather. It is the reason also, for the comparatively clear skies and dry weather of anti-cyclonic regions; since the cool dry air flowing from the higher regions downward and outward has its temperature raised and is enabled to take up into invisible suspension much of the moisture that it encounters, thus producing a comparatively dry atmosphere and clear skies. Naturally the farther we move from the center of circulation, whether cyclonic or anti-cyclonic, the less

marked these characteristics become. They may, moreover, be modified in many ways by local conditions of the land or sea over which they extend or over which they have passed; for all the features which would mark the weather of an ideal globe of uniform surface are modified in countless ways by the unequal distribution of land and water, and the varying physical features of both;—by currents, icebergs, etc., in the oceans; and by deserts, mountain ranges, and areas of forest or clearing on the land.

Thus the warm moist air over the Gulf Stream is chilled and turned into fog by contact with the cold Labrador Current off the Banks of Newfoundland. Similarly the southwest monsoon, charged with vapor from the tropical latitudes of the Indian Ocean, coming in contact with the cold heights of the Himalayas, precipitates its moisture in torrents of rain on the southern slopes of those mountains and passes on over the plains to the northward as dry as if it came from a desert. The proximity of a mountain range has always an important influence upon climate and weather.

GENERAL WIND CIRCULATION.

It would be natural to expect that in the great equatorial hot-belt, the phenomena of expansion from heat, of ascending currents with resulting low barometer, of condensation and precipitation of moisture, would be more frequent and more marked than elsewhere. Such is in fact the case; and Plate **125** shows clearly the great systems of steady indrawing Trades tnat meet in the region of equatorial rains and calms, and the connection of these with the great and generally permanent areas of high and low barometer that have been referred to as largely determining the circulation of the atmosphere about the globe.

As the Trades approach the equator there are constant little rising currents marked by the characteristic trade wind clouds; and in the region of permanent low pressure, calms, clouds and rain, which we have called the equatorial belt, but which is commonly known as the "Doldrums," they meet and rise, generally quietly and steadily but sometimes in the great eddies or whirlwinds with which we are familiar as tropical cyclones.

The tendency of the trades toward the equator from the north and south results naturally enough from the conditions which

have been described as prevailing in the equatorial belt; but explanation is required of the westward component in these winds, as well as of the unvarying regularity with which the winds of cyclones turn always in one direction in the northern hemisphere and in the opposite direction in the southern, while for anti-cyclones these directions are reversed.

The theory which is commonly accepted accounts for all of these phenomena by the rotation of the earth.

As the earth revolves from west to east the envelope of air surrounding it shares its motion, but may in addition have a motion of its own. If we imagine a particle of air moving from some point in north latitude toward the equator, it is clear that the particle will in the beginning have an eastward velocity equal to that of the spot from which it starts; but that as it moves toward the equator it will find the earth beneath it turning more and more rapidly (in linear velocity) and, failing to take up entirely this increased velocity, will lag behind and manifest itself as a wind from the northward and eastward. That is to say, it will be continually diverted to the right as it moves southward.

A particle of air moving from the equator northward, will, on the other hand, start out with the eastward velocity of the earth at the equator, and will thus outrun the more slowly moving surface over which it passes as it travels northward. Thus this particle will also be diverted to the right. And so with every particle of air which we may suppose to be moving in the northern hemisphere along any line except one due east and west. To some extent it will have a tendency to turn to the right. In Plate **127** are shown a number of such particles moving toward a common center of low barometric pressure, and forming inevitably a left-handed swirl (Fig. 2).

Similar considerations will make it clear why the winds flowing outward from a "high" revolve in the opposite direction, and why all these conditions are reversed in southern latitudes.

The following simple law, first enunciated by Buys-Ballot, puts in convenient form the relation between pressure and wind circulation.

When facing the wind, in the northern hemisphere the pressure is lower on your right hand and higher on your left; and conversely, in the southern hemisphere, it is higher on the right and lower on the left. This rule, it should be noted. applies to winds in general; not alone to storms.

Observations of winds, temperatures and pressures extending over a long period of years indicate the existence in the polar regions of an area of low barometer about which the winds circulate with the characteristic cyclonic direction, giving rise to the "Westerlies" or "Passage Winds" of the regions north and south of the Trades.

It is clear, of course, that this condition cannot be due to the causes which produce the low pressure in the equatorial region; and the commonly accepted theory accounts for it as a result of the centrifugal force acting upon the mass of the atmosphere as it is whirled about by the earth's rotation on its axis. Whether this be the true explanation or not, there is abundant evidence that the pressure is low at the poles as well as at the equator and that there exists an intermediate belt of generally high pressure in the neighborhood of 30° of latitude, from which the air tends to draw—on the one hand toward the equator, on the other toward the poles. This belt of high pressure, of comparative calms, and of baffling winds, while not always well marked over the continents, can be clearly traced across the ocean, where it is well known to navigators under the name of the "Horse Latitudes."

The winds blowing about and toward the poles take up the characteristic motion which has been explained, and there results, in latitudes above (approximately) 35° north and south, a steady flow of the atmosphere toward the east. At the earth's surface, this flow is often delayed, arrested, and turned back to the westward by local and temporary causes, but in the upper regions of the atmosphere it continues without interruption though not with unvarying velocity.

In this continued eastward movement of the air is to be found the key to the fluctuations of weather which (for example) sweep across the continent of North America and the North Atlantic Ocean; as well as the possibility of predicting from day to day approximately what weather may be expected at any given place. Disturbances of the atmosphere—highs and lows, with the weather features which have been described as characterizing them—sweep across the continent in a regular procession, following paths which may vary considerably, but are always toward the eastward. These disturbances may originate within the limits of the continent or may enter it from the Pacific; but they invariably leave it by the Atlantic sea-

board and usually by way of the New England coast or the Gulf of St. Lawrence (see Plate 127). An examination of the weather maps published by the United States Government for several successive days gives an interesting view of this progression of varying weather characteristics toward the east, and makes clear in a general way the laws upon which weather forecasting is based. Plate 128 shows a map of this kind. The corresponding map for the following day would show the successive highs and lows as having moved to the eastward, carrying with them their characteristic features of wind-circulation, temperature, cloud or clear sky, precipitation, etc.

The following description of the daily weather map is from a leaflet published by the Weather Bureau:

This map presents an outline of the United States and Canada, showing the stations where weather observations are taken daily at 8 A. M. and 8 P. M., seventy-fifth meridian time. These observations consist of readings of the barometer, thermometer (dry and wet), direction and velocity of wind, state of weather, amount, kind and direction of the clouds, and amount of rain or snow; they are telegraphed to Washington and to many of the Weather Bureau stations throughout the country for publication on the maps. Solid lines, called isobars, are drawn through points having the same atmospheric pressure; a separate line being drawn for each difference of one-tenth of an inch in the height of the barometer. Dotted lines, called isotherms, connecting places having the same temperature, are drawn for each ten degrees of the thermometer. Heavy dotted lines, inclosing areas where a decided change in temperature has occurred within the last twenty-four hours, are sometimes added. The direction of the wind is indicated by an arrow flying with the wind, or opposite to the ordinary vane. The state of weather—whether clear, partly cloudy, cloudy, raining, or snowing—is indicated by the circular symbol. Shaded areas, when used, show where rain or snow has fallen since the last observation.

The general movement of storms in the United States is from west to east, similar to a series of atmospheric waves, of which the crests are designated on the map " Highs," and the troughs or depressions " Lows." These alternating Highs and Lows have an average easterly movement of about 600 miles per day.

High winds, with rain or snow, usually precede the Low area, often extending to a distance of 600 miles to the eastward of the center of the storm. In advance of the Low the winds are generally southerly, and consequently bring high temperature. When the center of the Low passes to the east of a place, the wind at once shifts to the west or northwest, bringing lower temperature. The temperature on a given parallel west of the Low may be reasonably looked for on the same parallel to the east when the Low has passed, and frost will occur along and north of an isotherm of about 40°, if the night is clear and there is but little

wind. Following the Low usually comes an area of High, bringing sunshiny weather, which in its turn is followed by another Low.

By bearing in mind a few general rules as to the direction and rate of movement of the Low and High, with the blowing of the wind from the High toward the Low, and studying the map carefully, coming weather changes may frequently be foreseen. The centers of Lows do not, as a rule, move across isotherms, but follow their general direction. Areas of low pressure frequently move to the south of east from the Rocky Mountains to the Mississippi and then change direction to the north of east over the eastern half of the country. Storms in the Gulf of Mexico occasionally move to the west or north of west, but after reaching the coast, they generally change direction and move to the northeastward. High areas move to the southeast and are usually attended by fair and cool or cold weather. A cold wave is always accompanied by a High.

The cloud and rain area in front of a Low is generally about the size of the latter and oval, with the west side touching the center of the Low in advance of which it progresses.

When the isotherms run nearly east and west no decided change in temperature will occur. If the isotherms directly west of a place incline from northwest to southeast, it will be warmer; if from northeast to southwest it will be colder. Southerly to easterly winds prevail west of a nearly north and south line passing through the middle of a High, also east of a like line passing through the middle of a Low. Northerly to westerly winds occur west of a nearly north and south line passing through the middle of a Low and also east of a similar one through the middle of a High.

An absence of decided waves of High or troughs of Low pressure indicates a continuance of existing weather which will last till later maps show a change, usually first appearing in the west.

The temperature of the air as published on the map is observed with a dry-bulb thermometer, and also with a wet-bulb thermometer—that is, one whose bulb is covered with a moist wrapping. The evaporation from the wetter surface, if the air is not saturated with moisture, is more rapid than from the dry bulb, in proportion to the relative amount of aqueous vapor in the air. The difference of temperature between the readings of these two thermometers suffices to compute the relative humidity of the atmosphere. The temperature of the wet bulb is lower than that of the air as given by the dry-bulb thermometer, on account of the evaporation from its bulb. The wet-bulb temperature is sometimes called the sensible temperature, because the sensation of heat on the skin agrees more closely with its indications than with those of the dry thermometer.

A study of these charts, with their succession of highs and lows will make it clear why bad weather in the eastern part of the United States almost invariably begins with an easterly wind and clears with a cold northwester.

It should be noted that highs and lows must of necessity

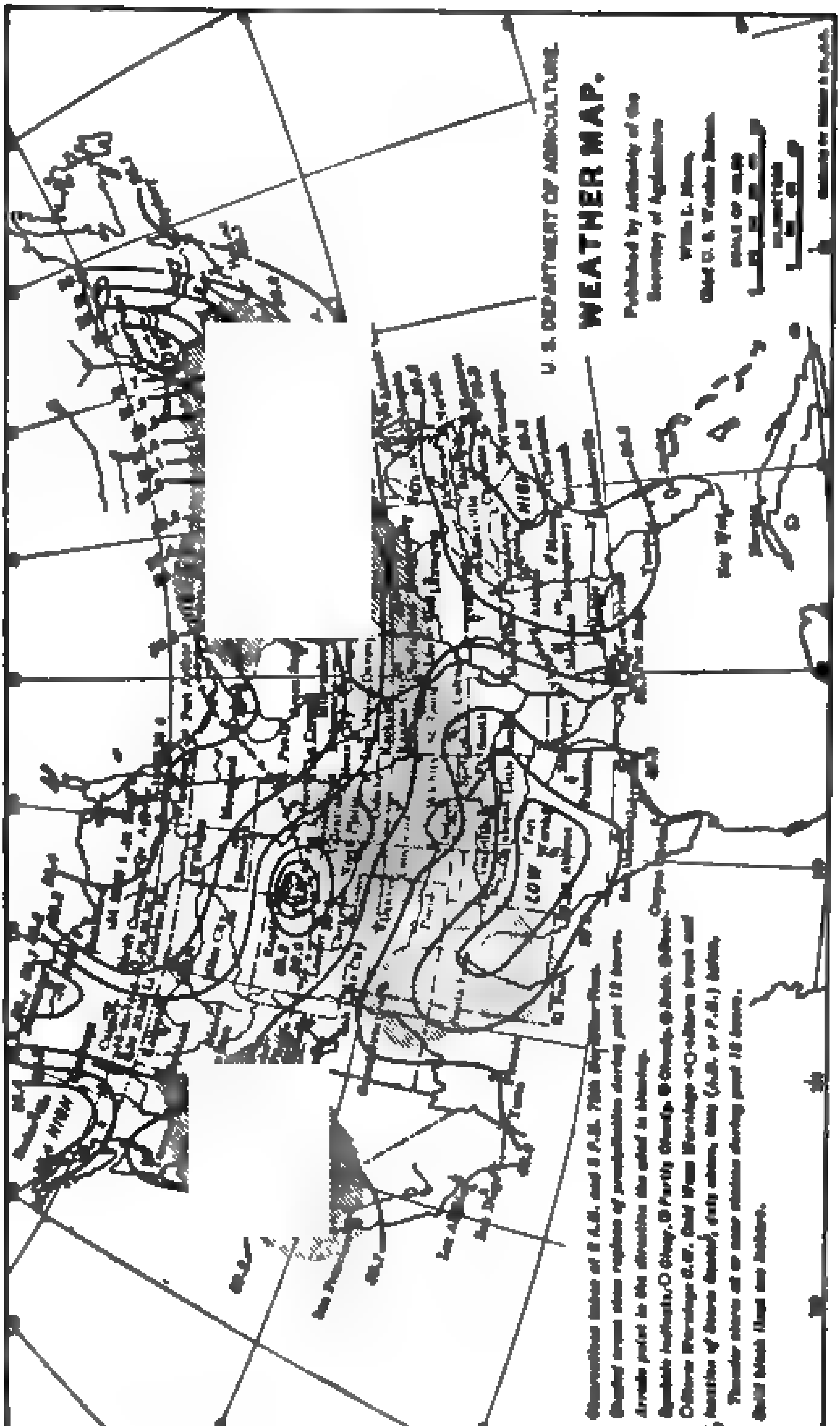
accompany each other, since the inward draft of air in a low implies the existence of a neighboring high, from which the wind flows outward. The relation between the two is shown in Fig. 1, Plate 126.

After the circulation of the winds, the most interesting and important features in connection with weather changes are the phenomena of precipitation, and temperature changes. It has already been explained why there is a tendency toward precipitation in the upward draft of a low; but it is found that in the case of the lows moving to the eastward across the United States, the precipitation is much greater along the forward part of the storm and in its eastern and southern quadrants than to the northward and westward. The explanation of this is that the winds of the eastern and southern quadrants are largely drawn from the warm regions of the southern states and from the Gulf of Mexico, and are charged with moisture which they deposit as they sweep northward and rise at the same time into the cooler regions of the upper atmosphere. This explains why, in north latitudes, rain comes with an easterly or southerly wind.

The winds of the northern and western quadrants are relatively dry and cold.

The same explanation suffices in a general way to account for the succession of cool and warm waves which are the more or less marked accompaniments of the *highs* and *lows*. It has already been explained that a *low* is, in its essential nature, an area of upward tending warm air, while a *high* is an area of downward-flowing cold air. But an inspection of our weather maps will show that in addition to this we have, on the forward side of an advancing low, a southerly or southeasterly wind, drawing up from the warm regions of the tropics; while the front of a high is made up of northerly winds sweeping down from British America.

Where a low originates in the tropics, it moves at first westward instead of eastward, being carried along by the general movement of the atmosphere. At the same time it works more or less toward the north (or south) and in the end becomes involved in the eastward current above described. Under the influence of this current it recurves and sweeps off to the east-


U. S. DEPARTMENT OF AGRICULTURE
WEATHER MAP.

ward, taking its place in the procession of highs and lows which have already been discussed.

The laws of atmospheric circulation which have been outlined above are subject to many exceptions and modifications, due to the irregular distribution of land and water and to other circumstances which break up the symmetry of an ideal globe. The predominance of land in the northern as compared with the southern hemisphere is the most important factor in modifying the general law.

Of the modifications thus introduced, the most marked and important is the enormous change over the continent of Asia from winter to summer, causing the phenomenon known as the reversal of the monsoons;—a phenomenon which is of vital importance to half the inhabitants of the globe.

This extensive continental area is excessively heated during the summer months and the air in contact with its surface becomes heated and rises, creating an upward draft of sufficient power to overcome the effect of the similar draft in the equatorial belt and to turn back the N.E. trade wind on its track, converting it into a S.W. "monsoon" which blows steadily and often violently, for several months of the year; after which, the continent having cooled down sufficiently to restore the normal balance of pressures, the trade wind again sets in;—under the local name of the N.E. monsoon.

These phenomena are strictly analogous to the alternation of land and sea breezes which characterize the summer climate of nearly all sea coasts. The land becomes abnormally heated during the day, the air above it rises, and a breeze draws in from seaward which continues until toward evening. During the night the land radiates its heat more rapidly than the water, the relative temperature and barometric conditions are reversed, and the land-breeze springs up and blows throughout the night.

Reverting once more to Plate **125**, attention may be called to the marked contrast between winter and summer conditions throughout the earth's surface, as regards not only temperatures, but pressures and wind-circulation as well.

It will be noted that the winter storms of the North Atlantic are not usually tropical in their origin, but begin, as a rule,

in the region of westerly winds and sweep across, usually well to the northward, following the general course of these winds. They are, in fact, in many if not most instances, identical with storms which have already swept across the North American continent; and in some cases it is possible to trace their history far back over the Pacific.

If it were possible to add still more data to Plate 125, it would be of interest to show the average amount of cloud, winter and summer; the precipitation in the form of rain or snow; the regions of maximum and minimum departure from normal temperature and pressure, and the amount of such departure; and the average daily range of the thermometer and barometer, together with the daily barometric tides. Were such data added it would be seen that the cloudy rainy regions are those of the equatorial calm belt and the high latitudes of the temperate zones, where low pressures indicate ascending currents; and that the tolerably clear regions are the belts of high pressure along the 30th parallels, with more cloudiness over the oceans and less over the continents, but entirely clear skies over the great deserts and in the lee of mountain ranges only. The rainfall data would show clearly the influence of prevailing winds in carrying moisture from the oceans to the continents, sometimes far inland over level land, sometimes only as far as a mountain range that chills and precipitates the aqueous vapor. The winds carry the temperatures, too, of the oceans they traverse, and thus modify weather and climate, with a tendency toward warmth rather than cold, inasmuch as the condensation of the vapor which they carry sets free large quantities of latent heat. Where storm tracks are numerous the rainfall is heavy; witness the case of cyclones which carry moisture with them from the Bay of Bengal to the foothills of the Himalayas producing rainfalls of 30 and even 40 inches a day, which may be contrasted with an average daily rainfall of $\frac{1}{10}$ inch in most parts of the United States. The great variations from normal temperature and pressure that occur in the stormy high latitudes of the temperate zones contrast forcibly with the uniformity and regularity within the tropics. The daily range of the thermometer depends on whether it is winter or summer, clear or cloudy; that of the barometer, on the position of the region relative to the tracks and number of passing cyclones

and anti-cyclones. The barometric tides, slight in themselves but moving in the equatorial regions with the regularity of clockwork, with daily forenoon and evening maxima and early morning and evening minima, are often obscured in higher latitudes by the far greater changes due to passing storms, and are modified a little everywhere by the effect of continents close by. All of these phenomena, so closely inter-related, may be studied in connection with the fundamental data represented graphically in Plate 125.

THE BAROMETER.

It will be evident from what precedes, that the barometer is beyond comparison the most important of the instruments available for forecasting weather, and that it is deserving of much more exact attention than it commonly receives on shipboard. It should be carefully placed where it will hang vertically and be subject to a temperature not widely different from that of the outside air. A thermometer should be attached to it or placed near it, and the temperature indicated by this thermometer entered with every reading of the barometer recorded. Comparison should be made from time to time with a standard barometer in ports where such an instrument can be found. For this comparison it is not necessary to bring the instruments together, but only to get practically simultaneous readings and to apply the proper corrections for temperature. A comparison carefully made, with the proper corrections, gives an instrumental error which may be checked from time to time as opportunity permits, and makes it possible to compare the readings of the instrument with data published on Weather Charts and in Sailing Directions, as well as to furnish additional reliable data for publications of that kind.

It will add to one's interest in keeping a good barometric log to know that others can easily check its accuracy, both at once and years hence. For instance, suppose you make a voyage from New York to Liverpool, thence to Hamburg, Cape Town, Melbourne, and Yokohama. Whenever you pass within a few miles of another vessel, or of any port or coast of a country where daily weather maps are published (such as the United States, England, Germany, France, Cape Colony, Australia, and Japan), a comparison of your log with other good logs, or with the published observations that are available in the libraries of government and other offices all over the world, will give any one that chooses to make it, a perfect check on your record. If it stands the test, it becomes a

good check on other logs and valuable for study. Very few aneroids will stand this rigid and long-continued test of reliability, however useful they may be in showing changes of pressure from time to time in practical use at sea.

To draw conclusions from the reading of the barometer we must know the normal pressure of the place and time of observation. These are shown for mid-winter and mid-summer in most parts of the world on Plate **125**, and should be given for all places and seasons in Sailing Directions. The importance of this point is indicated by the fact that a corrected pressure of 29.40 is normal for high southern latitudes, but very low for corresponding latitudes north.

The normal pressure at any given place may be expected to show the regular daily fluctuation or "barometric tide," already referred to, and which is entirely independent of variations connected with the weather. This fluctuation is greatest in the tropics and disappears in very high latitudes both north and south. The extreme daily range in the tropics is in the neighborhood of $\frac{1}{10}$ of an inch. The maxima occur about 10 o'clock, the minima about 4 o'clock, A. M., and P. M. Apart from the daily tides, the variations in barometric pressure are slight within the tropics, while in high latitudes they are very marked.

CLOUDS.

The relation of cloud-forms of various kinds to weather, either existing or in prospect, is a matter of the greatest importance; but unfortunately our knowledge upon this subject is still very limited. The usual classification of cloud-forms is shown in Plate **129**, and the following notes give in condensed shape about all that is known with regard to their significance.

DESCRIPTION OF CLOUD-FORMS (Plate 129).

The following cloud-forms are arranged according to a general descending scale of altitude, observation having shown that there are five main cloud levels; viz.: cirrus (highest), cirro-cumulus, alto-cumulus, cumulus, and stratus (lowest).

1. **Cirrus (Ci.).**—Detached clouds, delicate and fibrous looking, taking the form of feathers, generally of a white color, sometimes arranged in belts which cross a portion of the sky in great circles, and, by an effect of perspective, converge toward one or two opposite points of the horizon. (The Ci.-S. and the Ci.-Cu. often contribute to the formation of these belts). The height of cirrus is from 5 to 6 miles.

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PRINCIPAL FORMS OF CLOUDS (AFTER KÖPPEN).

Plate No. 129.

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PRINCIPAL FORMS OF CLOUDS (AFTER KÖPPEN).

Reproduced from Waldo's "Elementary Meteorology" by permission of American Book Company.

2. **Cirro-Stratus (Ci.-S.).**—A thin, whitish sheet, at times completely covering the sky and only giving it a whitish appearance (it is then sometimes called cirronebula), or at others presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon. Average height about 5½ miles.

3. **Cirro-Cumulus (Ci.-Cu.).**—Small globular masses, or white flakes without shadows, or having very slight shadows, arranged in groups and often in lines. Height about 4 miles.

4. **Alto-Cumulus (A.-Cu.).**—Rather large globular masses, white or grayish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused. The detached masses are generally larger and more compact (changing to S.-Cu.) at the center of the group; at the margin they form into finer flakes (changing to Ci.-Cu.). They often spread themselves out in lines in one or two directions.

5. **Alto-Stratus (A.-S.).**—A thick sheet of a gray or bluish color, showing a brilliant patch in the neighborhood of the sun or moon, and which, without causing halos, may give rise to coronæ. This form goes through all the changes like the Cirro-stratus, but, by measurements made at Upsala, its altitude is one-half less. Height about 3 miles.

6. **Strato-Cumulus (S.-Cu.).**—Large globular masses or rolls of dark cloud, frequently covering the whole sky, especially in winter, and occasionally giving it a wavy appearance. The layer of Strato-cumulus is not, as a rule, very thick, and patches of blue sky are often visible through the intervening spaces. All sorts of transitions between this form and the Alto-cumulus are noticeable. It may be distinguished from Nimbus by its globular or rolled appearance, and also because it does not bring rain. Average height about 1 mile.

7. **Nimbus (N.).**—Rain clouds.—A thick layer of dark clouds, without shape and with ragged edges, from which continued rain or snow generally falls. Through the openings of these clouds an upper layer of Cirro-stratus or Alto-stratus may almost invariably be seen. If the layer of Nimbus separates into shreds, or if small loose clouds are visible floating at a low level, underneath a large nimbus, they may be described as Fracto-nimbus (Fr.-N.), "Scud" of sailors.

8. **Cumulus (Cu.).**—Wool-pack clouds.—Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal. These clouds appear to be formed by a diurnal ascensional movement which is almost always observable. When the cloud is opposite the sun, the surfaces usually presented to the observer have a greater brilliance than the margins of the protuberances. When the light falls aslant, these clouds give deep shadows; when, on the contrary, the clouds are on the same side as the sun, they appear dark, with bright edges.

The true Cumulus has clear superior and inferior limits. It is often broken up by strong winds, and the detached portions undergo continual changes. These may be distinguished by the name of Fracto-cumulus (Fr.-Cu.).

9. **Cumulo-Nimbus (Cu.-N.).**—The Thunder-cloud; Shower-cloud.—Heavy masses of clouds rising in the form of mountains, turrets, or anvils, generally having a sheet or screen of fibrous appearance above

(" false Cirrus "), and underneath, a mass of cloud similar to " Nimbus." From the base there usually fall local showers of rain or of snow (occasionally hail or soft hail). Sometimes the upper edges have the compact form of Cumulus, forming into massive peaks round which the delicate " false Cirrus " floats, and sometimes the edges themselves separate into a fringe of filaments similar to that of the Cirrus cloud. This last form is particularly common in spring showers.

The front of thunderclouds of wide extent frequently presents the form of a large bow spread over a portion of the sky which is uniformly brighter in color.

10. **Stratus (S.).**—A horizontal sheet of lifted Fog.—When this sheet is broken up into irregular shreds by the wind, or by the summits of mountains, it may be distinguished by the name of Fracto-stratus (Fr.-S.).

NOTE.—The attention of mariners is especially called to the value of observations of cirrus, as this form of cloud is often closely connected with barometric depressions. If the cirrus occurs in radiating bands crossing the sky, the point of convergence of these bands should be noted; if in the form of a cloud bank, or sheet, upon the horizon, the center, or point of greatest density of this bank; as this point will sometimes serve to indicate in a general manner the direction of the center of any cyclonic disturbance.

§ II. THE LAW OF STORMS.

The general features of this law have been enunciated in the preceding pages; for the storms with which the law deals (in its special application to Seamanship), are simply cyclones or *lows* like those already described, but with all their characteristic features intensified and concentrated within comparatively narrow limits.

These storms, variously known as "Cyclones," "Typhoons," "Tropical Hurricanes," etc., have their origin over the ocean and on the border-land between the equatorial hot-belt and the trade-wind region, where unsettled conditions would naturally be expected to prevail. Many theories have been put forward to explain their origin, but none which is entirely satisfactory. The generally accepted theory connects the development of the disturbance with the existence, as a preliminary, of excessively sultry, rainy, and squally conditions in the lower layers of the atmosphere, and the coincidence in the upper layers, of temperatures lower than those due to the normal decrease of temperature with the altitude. This is evidently a condition of unstable equilibrium and sooner or later results in the formation of ascending currents and a general overturning of the atmosphere, with a sudden and violent inrush of air from all the

FIG. I. WIND CIRCULATION IN HURRICANE, NORTHERN HEMISPHERE.

FIG. 2.
CROSS-SECTION OF HURRICANE, SHOWING CLOUD-BANK, CENTRAL CALM AND STORM-WAVE.

surrounding regions. This action, once commenced, is increased in intensity by the formation of clouds and rain in the ascending air, resulting in the liberation of heat, which acts to increase still further the violence of the upward- and inward-rushing currents. The air flowing in takes up the characteristic cyclonic rotation which has already been described and explained, and the hurricane vortex is established, with extremely low pressure and a clear calm space of small diameter at the center. In this vortex and the surrounding whirl there are different degrees of rotation to the different layers of the atmosphere, beginning at the base with an inward spiral which diverges by perhaps two points from a circle (at a distance from the center) and ending at the top—many miles above the base—with currents radiating almost directly outward. An attempt is made to indicate this circulation in Plate 130. The successive layers of air are marked by different cloud-forms resulting from the special conditions to which the moisture in the swirl finds itself subjected. The lowest layer above that at the surface is marked by low fast-flying scud, which is observed to move in what is practically a circle; above this and diverging slightly outward is a layer of cumulus, and above this come in succession alto-stratus, cirro-cumulus, and in the rare, cool atmosphere six miles and more above the surface, the long feathery plumes of cirrus, radiating almost directly outward. Naturally, these successive layers of cloud are not distinguishable by an observer actually involved in the storm, as his view is bounded by the heavy scud over his head; but they can be more or less clearly made out from a distance, the cirrus clouds in particular being distinguishable above the heavy bank beneath, and indicating by the point from which they radiate, the bearing of the center of the storm. Great activity of movement in the upper clouds, observed while the center is still distant, indicates a storm of great severity. If the cirrus plumes are faint, fading gradually behind the slowly thickening veil, the storm is an old one of large area; if they are of snowy whiteness, projected against a clear blue sky, it is young and of small area, but of great intensity. The general direction of translation is at first toward the west, but with a slight tendency away from the equator which becomes more and more marked, until the storm sweeps around altogether, and, in the region of westerly winds, moves off to the eastward. The velocity of translation

Fig. 1
Sept. 6, 8 A. M.

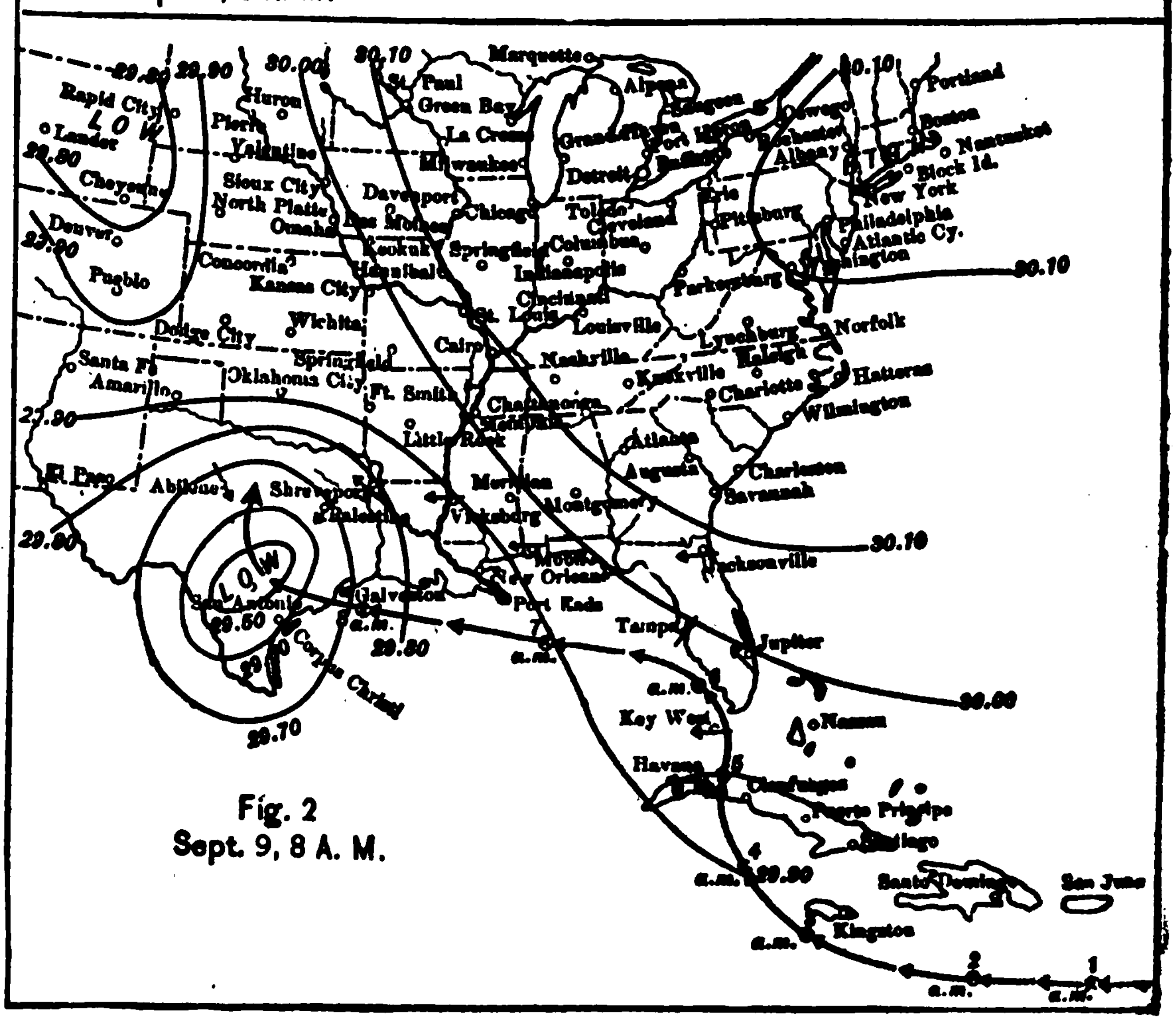


Fig. 2
Sept. 9, 8 A. M.

GALVESTON HURRICANE SEPTEMBER 1900.

varies from a few miles an hour to as much as twenty-five or thirty miles, being greatly affected by the barometric pressures prevailing *in the regions towards which it is advancing.* Thus a storm advancing toward the Atlantic coast of the United States may find prevailing over the continent and the coasts, an area of very high barometer against which it comes up as against an elastic but impenetrable barrier. It may thus be slowed down and held back, or, as frequently occurs, shunted off to one side and entirely changed in direction. A striking example of this kind is shown on Plate **131**, where a cyclone which was apparently marked out for a track along the Atlantic coast found its path blocked by a "High" and was finally driven off onto the west Gulf Coast, where it entirely destroyed the city of Galveston. This effect is similar to that of the fixed area of permanent high barometer shown on Plate **125** as overhanging the North Atlantic Ocean during the summer months. The storms of this season follow around the outside limits of this area, the existence of which undoubtedly counts for much in determining their course. Their track, in fact, is usually along a trough of low pressure between two highs, one overhanging the ocean, the other the land. Other factors of importance in determining the track of the storms, are the general circulation of the atmosphere, with which they tend to move along, and the existence of such ocean currents as the Gulf Stream in the North Atlantic and the Japanese Current in the North Pacific; the excessive evaporation over these currents tending to create a trough of low pressure such as has been referred to above. The track of such a storm in the North Atlantic is shown in Plate **132**, in which are brought out many points of interest and importance in connection with its progress and development. It will be noted that the shape of the storm, far from being a circle, is a decided ellipse, with a well-marked trough of low pressure along its major axis. In the early stages of its progress the storm is of small area but great intensity. As it progresses, it spreads out and, usually, loses something of its violence; (as is indicated by the increasing distance between the isobars), and in the end sweeps across the North Atlantic as a southeasterly gale with a northwester following close upon it. Taken as a whole, the storm here shown is a summer type, but in the final part of its path it represents also the winter storms of the North Atlantic.

Plate No. 132.

OCEAN CYCLONES AND ANTI-CYCLONES OF THE NORTHERN HEMISPHERE

A Diagram of Typical Wind Circulation from Anti-cyclones to and around Cyclonic Storm Centers in Oceans North of the Equator, and the Tracks along which Storms Usually Move

(*Facing page* 496)

which are none the less cyclonic because they do not originate in the tropics.

Strictly speaking, we should consider this chart to represent, not the progress of a single storm on a number of successive days, but a number of storms existing at the same time. This is not an impossible condition of affairs, although it would of course be an unusual one. For our present purpose, however, we may imagine that the "high" which is shown as hanging over the western part of the area included by the chart has remained stationary for several days (a phenomenon which is not uncommon) and that the storm has made its way through the trough between this high and the permanent anti-cyclone to the eastward.

The chart illustrates the conditions of weather characterizing each portion of the storm, and can be made to show the changes which would be encountered by a vessel passing through the storm along any given line, or lying to and allowing the storm to pass over her. An inspection of this chart will explain most of the characteristic features of bad weather in the North Atlantic; showing why gales commonly begin with the wind at east or southeast and end with it at N.W.; and why the change from one quarter to the other often comes in a sudden shift with violent squalls. This shift is due to the passage of the trough of low pressure into which the originally circular center has been stretched out. (Compare with Plate **127**.)

Among the weather proverbs most firmly believed in by sea-faring men is the one which insists that good weather is not to be expected after a storm in the northern hemisphere if the wind shifts to the left, or *backs*. It will be clear from what precedes, that this is true only for observers in the right-hand semi-circle of the storm. In this semi-circle, as has been shown, the wind shifts to the right as the storm passes, and goes to Northwest by way of South, Southwest and West. In the left-hand semi-circle, on the other hand, the northwest weather of the clear anti-cyclone follows a shift to the left, through Northeast and North.

It happens, however, that the Atlantic and Gulf Coasts of the United States, and the greater part of Europe (including England) lie to the south and east of the average path of the storms to which these regions are subject; and the same is true of the ordinary tracks of vessels in the North Atlantic. Thus it happens that with regard to a very large majority of the storms moving over these regions, observers find themselves in the right-hand semi-circle; and do, as a matter of fact, get their clearing weather by a shift of the wind to the right. This is not true of tropical hurricanes, but it must be remembered that these are few in number in comparison with the storms which originate in higher latitudes. (See Plate 134.)

The velocity of translation of storms varies within wide limits and it is very unsafe to assume even an approximate value for it in any given case. It may be said, however, that the *average* velocity per hour within the tropics is between 15 and 20 knots; that as the storms turn toward the north (or south) they slow down, the average for this part of the path being from 5 to 6 knots; and that as they recurve and start off to the eastward, the velocity usually increases, the average for this part of the track being something like 25 knots. The maximum velocity that has been observed does not much exceed 30 knots. The velocity of rotation varies from 50 to 100 miles an hour and perhaps even more than this. It is evident that on one side of the track, or in one semi-circle of the storm, the velocity of translation will be added to that of rotation, while in the other semi-circle it will be subtracted. This is one of the most important reasons for regarding one semi-circle as "dangerous" and the other as "manageable." Other reasons are that this is the side toward which the storm-track curves, and that on this side the winds and currents tend to set the vessel toward the front of the storm-center.

Rules are sometimes laid down as to the latitude of recurving of storms at different seasons of the year; but such rules are even more dangerous than those which deal with the velocity of translation. The storm tracks plotted on Plate **134** give all the data that are available on this subject, and indicate clearly enough that no rule can be laid down which will not be subject to so many exceptions as to render it altogether valueless.

Plate **130** illustrates on an exaggerated vertical sectional scale the cloud formation, wind circulation and storm wave of a hurricane. The mountainous central mass of cloud, composed of heavy nimbus below and towering leaden cumulus above, often maintains a remarkable fixity of bearing, which, together with its solid rugged appearance, makes it look like distant land. Such a cloud-bank was once visible from Trinidad, Cuba, for five entire days.

The storm wave, or general rise of the level of the sea near the center, due to the inrushing winds and low pressure, moves along with the storm until perhaps precipitated in a great flood upon islands and coasts in its path. Such a flood, the night of

October 31, 1876, in the low lands of the delta of the Ganges, drowned 100,000 people and resulted in the death of as many more through famine and disease. Very strong currents are caused both by the wind force and, apparently, by the advance of the entire storm, which seems to drive the sea bodily before it as well as drag it along behind. Near the coast these effects are most marked, and after a few days in a hurricane, vessels often find themselves 50 or 100 miles out of their reckoning. The widest allowances must therefore be made for current, until the weather clears and good sights can be obtained.

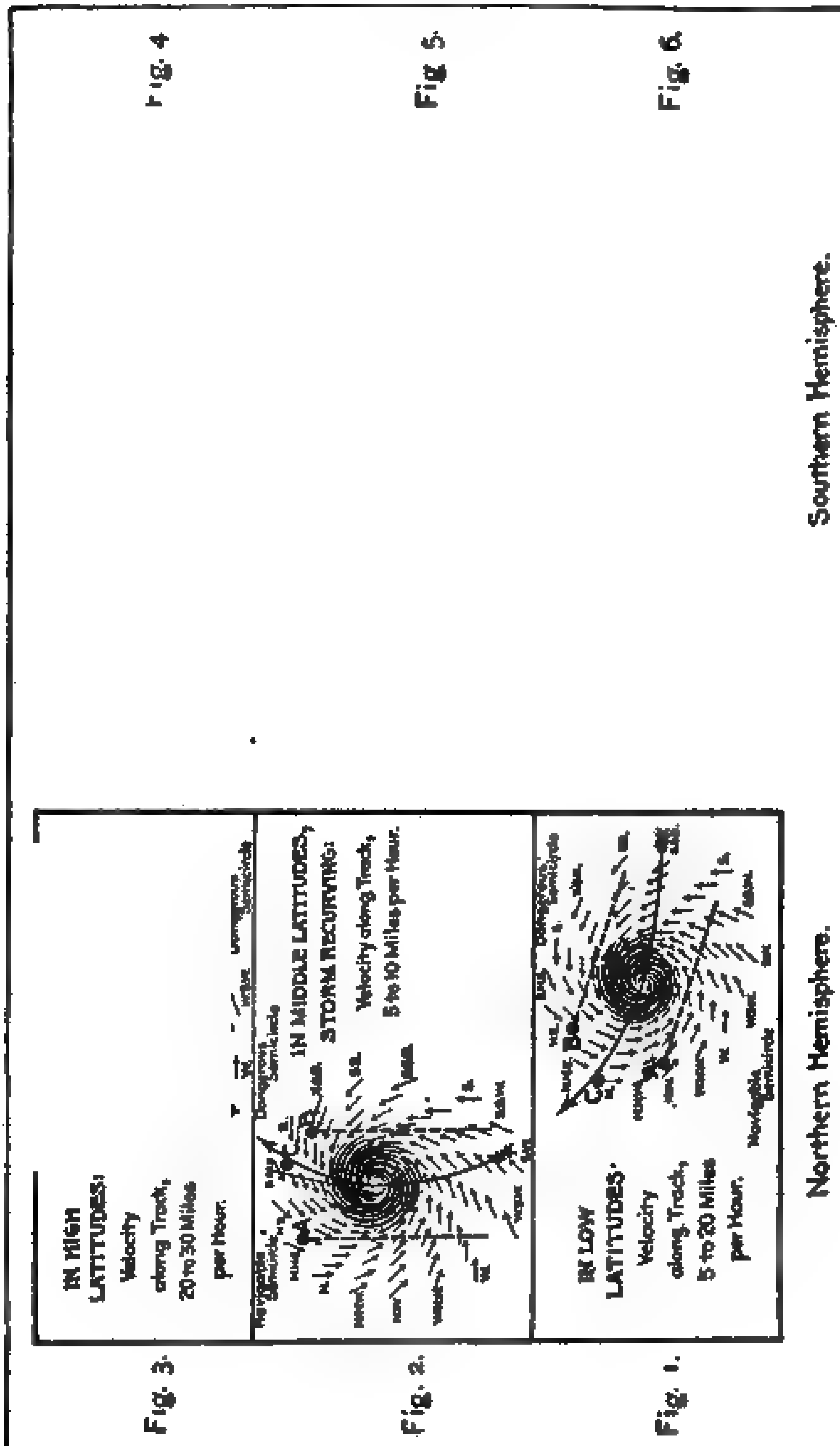
Indications of the Approach of a Hurricane.

Earliest indications.—The distant storm usually causes an abnormal *rise* of the barometer, with cool, dry, fresh winds and cessation or reversal of the ordinary land and sea breezes, with a very transparent atmosphere. A long low swell is often noticed at a great distance, sometimes hundreds of miles, with occasional high hurricane rollers. The direction of the swell, when unaffected by intervening islands and neighboring coasts, indicates the bearing of the center; as do also the light feathery plumes of cirrus cloud that radiate from a point of the horizon marked by a whitish arc.

Unmistakable signs.—As the sky becomes hazy with a thin uniform cirrus veil, halos are noticed by day and night, the barometer begins to fall slowly, the air becomes heavy, hot and moist, with red and violet tints at dawn and sunset; the low but solid and rugged looking cloud-bank of the hurricane appears on the horizon like distant land; squalls break off and diverge from it, and later squalls are noticed passing across the line of bearing of the center of the bank. Fine misty rain forms, seeming to grow out of the atmosphere; a heavy cross sea is felt, and the barometer, while falling rapidly, becomes unsteady.

A vessel situated in front of and near the path of a cyclonic storm will commonly experience a long, heavy swell, a falling barometer with heavy rain, and increasing winds, the direction and changes of which will depend upon her position with reference to the center and the track. A comparison of the three positions of a storm plotted in Plate 133 will show that whereas in Fig. 1, a wind from N.E. or E.N.E. marks a position near

Plate No. 188.



A HURRICANE RECURVING.

B, in the forward right-hand quadrant (the most dangerous part of the storm), in Fig. 3, the same direction of the wind marks a position near A in the navigable semi-circle and clear of all real danger; while in Fig. 2, it marks a position near C, almost in the track of the storm. This shows the importance of considering the ship's position as to latitude and longitude, in connection with other data; but in attempting to draw conclusions from this it must not be forgotten that the latitude of recurving can be known only in a very general way.

Rules for Manœuvring.

The rules for manœuvring with reference to a storm have for their objects: 1st, to determine the bearing and distance of the center and the track along which it is moving; 2nd, to avoid the center and, if possible, to keep out of or escape from the dangerous semi-circle; 3d, to ride out the storm in safety if unable to escape from it.

It has been shown that the bearing of the center may in some cases be determined, while the storm is at a distance, by observations of the cloud-bank and especially of the point from which the cirrus plumes are seen to radiate; and in some cases, also, by the direction of the long swell which often precedes the storm. But these indications are confined to the early stages of the storm's advance, within the limits of the tropics. Under other circumstances, the only indications of value are the direction and force of the wind and the action of the barometer. The old rule for determining the bearing of the center was to assume it as eight points from the direction of the wind; to the right in the northern hemisphere and to the left in the southern. It is now known that this eight-point rule is true only near the center of the storm, and that near the edge, the center may bear as much as twelve points from the wind.

The following perhaps expresses as definitely as a rule can express it, this relation between the direction of the wind and the bearing of the center of the storm.

Rule.—When the approach of a revolving storm is first clearly recognized, the bearing of the center may be assumed as between 10 and 12 points from the direction of the wind. When the characteristic features of the storm are fully developed, the wind having the force of a gale and the barometer

falling steadily, the bearing may be assumed as between eight and ten points. As the storm continues to increase and after the barometer has fallen *as much as half an inch,* the bearing may be taken as about eight points.

It will be understood that neither this rule nor any other one can take the place of an intelligent comprehension and application of the principles which have been explained in the preceding pages.

For data as to the path of the storm, a vessel must heave-to and note the changes in the bearing of the center, and the fall of the barometer.

Plate **132** shows the changes in conditions which would be noted by vessels over which the storm is passing along the different lines there indicated. The hauling of the wind to the right indicates that the vessel is in the right-hand semi-circle; hauling to the left, that she is in the left-hand semi-circle.

This rule holds for both hemispheres; but whereas in the northern hemisphere the dangerous semi-circle is to the right, in the southern hemisphere it is to the left. In either hemisphere, if the wind continues from the same direction with a steadily falling barometer, the chances are that the ship is in the track of the storm. One important exception should, however, be noted. When a hurricane moves along the edge of a trade-wind or monsoon region, the prevailing winds are intensified over a wide area, without appreciable change in direction, giving rise to what are known as "intensified" trades or monsoons. These are illustrated in Fig. 1, Plate **135.** In this figure, a vessel at A, hove-to, would have a falling barometer, and no change in the direction of the wind. But if she infers that she is directly in front of the center, and runs before the wind, she plunges directly into the vortex. The only safe course under these conditions is to haul off to the right (in the particular case illustrated in the figure), carrying all the sail that is safe and gaining as much ground to that side as is possible before it becomes necessary to lie-to. *It must be remembered that this applies only to the exceptional case of a hurricane encountered on the border of a trade-wind or monsoon belt.*

It is not a matter of indifference on which tack a ship heaves-to while watching the wind, barometer, and clouds, and waiting for the situation to declare itself. Consider, for example, the ships of Fig. 2, Plate **135.** If the ship B, in the right-hand

STORM TRACKS

semi-circle, heaves-to on the starboard tack, the wind and sea will gradually draw aft. If she heaves-to on the port tack, they will draw ahead and she is liable to be taken aback, perhaps in a sudden and violent squall. In the left-hand semi-circle, the conditions are reversed; but here the danger is not in any case as great as in the other semi-circle. The rule is, therefore, in the northern hemisphere, to heave-to *in the beginning* on the starboard tack. If the wind shifts to the right, you are in the dangerous semi-circle and are on the proper tack. If circumstances admit, you may try to work away from the track of the center, close-hauled on the starboard tack. When obliged to lie-to, do so on the same tack.

If, being hove-to on the starboard tack, the wind hauls to the left (ahead), you are in the left-hand or manageable semi-circle, say at A, and heading away from the track of the center. Here you should bring the wind on the starboard quarter and run as long as possible. If obliged to lie-to, do so on the port tack, being careful to make as little headway as possible.

If, the ship being hove-to, the wind remains steady in direction and the barometer continues to fall, it may be assumed, except in the one case which has been discussed above, that the ship is in or near the path of the storm;—say at C. She should run with the wind on the starboard quarter and hold the compass course thus fixed until the barometer begins to rise.

Most of the above rules are reversed for the southern hemisphere. They are summarized for both hemispheres in the following table:

NORTHERN HEMISPHERE.

Heave-to on **Starboard Tack** to note Shift of Wind.

Wind hauls to right	**Ship is in right semi-circle** DANGEROUS.	**Run close hauled on starboard tack.** **When obliged to lie-to, do so on starboard tack.**
" " left	**Ship is in left semi-circle** **Manageable.**	**Run with wind on starboard quarter.** **If obliged to lie-to, do so on port tack.**
" continues steady	**Ship is in path of storm**	**Run with wind on starboard quarter and keep this compass course.** **If obliged to lie-to, do so on the tack on which wind and sea will draw aft.**

SOUTHERN HEMISPHERE.

Heave-to on **Port Tack** to note Shift of Wind.

Wind hauls to right	Ship is in right semi-circle Manageable.	Run with wind on port quarter. If obliged to lie-to, do so on starboard tack.
" " left	Ship is in left semi-circle DANGEROUS.	Run close hauled on port tack. When obliged to lie-to, do so on port tack.
" continues steady	Ship is in path of storm	Run with wind on port-quarter and keep this compass course. If obliged to lie-to, do so on the tack on which wind and sea will draw aft.

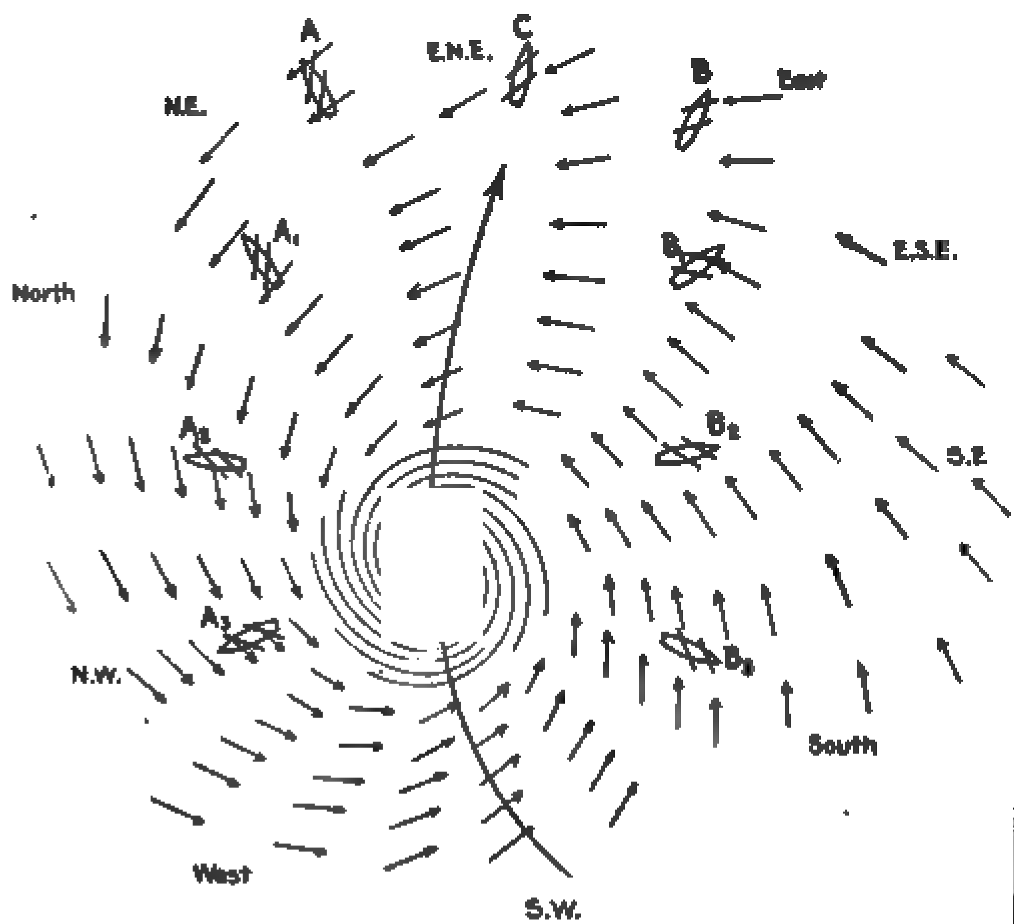
For plotting the position of the ship within the storm from time to time it is convenient to construct a storm-card like Fig. 2, Plate **135**. This should be on tracing cloth and on a good scale. The ship is then drawn on a sheet of paper and the storm-card moved over it in accordance with the motion of the center as determined from the successive observations made as above described. A rough estimate may generally be made of the distance of the center, from the character of the weather, the force of the wind, the fall of the barometer, etc.

It is hardly necessary to say that circumstances may require the modification of the foregoing rules in many directions. One of the most frequent reasons for such modifications is the proximity to land. The influence of this point upon the course to be adopted will be greatly affected by the way in which it is known that the wind will shift. There is less danger in closing with a coast if it is certain that the shifts of wind will be off-shore and not on. So with regard to seeking an anchorage. It may be safe to anchor in an open roadstead if the shifts of wind are bound to be such as to give a lee; it would be hazardous to anchor if the reverse were the case.

Naturally, also, the seaworthiness of the ship, her speed, and many other conditions, are factors in the problem of manœuvring.

The latitude in which the storm is encountered makes a difference because of the difference in intensity; and a vessel may

Example of Intensified Trade-Wind Belt.



A Cyclone in the Northern Hemisphere.

SHIFTS OF WIND IN A CYCLONE.

CYCLONES.

safely hold her course through a storm in the North Atlantic which she would take every means to avoid in the tropics. On the other hand, it is easier to avoid a storm in the tropics than in high latitudes, because of the difference in the area which it covers. The diameter of a hurricane in the tropics rarely exceeds 300 miles, while in high latitudes it may be a thousand miles or more.

The curvature of the track must be taken into consideration. Vessels have been known to escape from a slow-moving hurricane toward the concave side of the track, only to run into it again after it had recurved.

The preceding directions have especial reference to sailing vessels, but in their general principles they are perfectly applicable to steamers. There is, however, this important difference to be noted; that as a steamer is not dependent for her course upon the direction of the wind, she is much freer to manœuvre and may almost always, unless in the neighborhood of land, keep far enough from the center of the storm to avoid all serious danger. This, however, is true only when the storm is of comparatively limited area and with a center clearly defined; as in positions 1, 2, 3 and 4, of Plate **132**. It is evident that when the storm has spread out over thousands of miles, as in positions 5 and 6, with an elongated trough of low pressure in place of a sharply-defined center, it is hopeless for even a steamer to attempt to avoid it. In such a gale, the directions of the following Chapter (Handling a Steamer in Heavy Weather) become important; and if applied with some reference to the changes in weather which may be anticipated from a study of Plate **132**, they furnish all the directions which should be needed to carry a steamer through any gale in which she has a fair amount of sea-room.

Another point of difference between a steamer and a sailing vessel has to do with the rule for lying-to in the manageable semi-circle. The rule for a sailing ship is to lie-to on the "coming-up" tack in spite of the fact that this brings her head toward the center. For a steamer, the rule in general is to lie-to always with the head away from the center, in order that such headway as is made may be all in the direction of safety.

The Pilot Charts of the North Atlantic and North Pacific

Oceans, issued by the Hydrographic Office of the United States Navy Department, should be familiar to all mariners. These are in substance Monthly Weather Maps of the Ocean and contain a large amount of valuable information not elsewhere to be found, upon a great variety of topics.

Storm Signals.

Most of the civilized nations of the world give warning to mariners of the approach of storms. These notices are received by telegraph at various stations along the coast and indicate the approach of storms and the expected direction of the wind. In the United States the system of weather-signals is very complete, information of the approach of storms being received from various stations in the United States and even throughout the West Indies. These warnings are published at the various seaports by the display of flags by day and by lanterns at night, and by bulletins and reports furnished to newspapers. Every effort is made to give these warnings as early as possible at all points where they may be of service to mariners and others.

United States Storm Signals.—Storm signals are displayed by the United States Weather Bureau at a large number of stations situated on the coasts of the United States. Many of these stations are equipped for signalling by the International Code, and are prepared to transmit by telegraph the messages of passing vessels.

Storm-Warning Flags.—(a) A red flag, with a black center, indicates that a storm of marked violence is expected.

(b) The pennants displayed with the flags indicate the direction of the wind; red, easterly (from north, through east, to south); white, westerly (from south, through west, to north). The pennant above the flag indicates that the wind is expected to blow from the northerly quadrants; below, from southerly quadrants.

(c) By night a red light indicates easterly winds, and a white light below a red light, westerly winds.

Hurricane Warnings.—(a) Two red flags with black centers displayed one above the other indicate the expected approach of a tropical hurricane, and also of those extremely severe and dangerous storms which occasionally move across the lakes and northern Atlantic coast.

(b) Hurricane signals are not displayed at night.

CHAPTER XVIII.

HANDLING STEAMERS IN HEAVY WEATHER.

§ I.

The conventional way of handling a steamer when the weather is too heavy for her to proceed on her course is to bring her up until she has the sea on the bow and to hold her there by the engines and the helm, assisted by such after sail as may be available. In this position, most steamers have a constant tendency to fall off, and can only be held up by giving them way enough for the rudder to exercise considerable steering power. They are thus, to some extent, forced into the sea, and the more it is necessary to force them, the greater the strain to which they are subjected, and the greater the probability of their taking water on board in dangerous quantities. This method of riding out a gale has been handed down from the days of bluff-bowed sailing ships and of steamers with more or less complete sail power. Such ships were held up to wind and sea by their ample after sail, with little or no headway. If they fell off—as from time to time they did—and started to gather way, the hard down helm and after sail would bring them promptly back to meet the sea. Thus they came up and fell off, making some little way through the water, but none of it against the sea; and, in the main, drifting steadily to leeward. For such ships, this was and is the ideal way of riding out a gale. But a modern steamer, whether man-of-war, liner or tramp, carries very little after sail and is commonly long and sharp. The propeller acts as a drag, tending to hold her stern up to the sea, and this tendency is assisted by the excess of draft which such steamers usually have aft. To hold such a steamer bows on to the sea, she must be forced into it—not at great speed, perhaps, but sufficiently to strain the ship severely and to suggest grave doubt as to the wisdom of this method of lying to.

The opinion is gaining ground of late years that a steamer of this type should run slowly before a sea or lie to with the

sea astern or on the quarter; and this view is supported both by theoretical considerations and by a convincing amount of practical experience.

If we watch any buoyant object floating in waves which are of some size as compared with the object itself, we shall see that so long as it floats freely, it floats easily, with no indication of strain and with little or no wash on its upper surfaces. If it is forced to lie in some other position than that which it naturally takes, all this is changed; it ceases to ride easily, and the waves break over it more or less. If it is forced through the water, even on the heading which it naturally takes, signs of strain become apparent, and the sea washes over it. If it is forced *against* the sea, the wash will be greater than on any other course, and as the speed in this direction increases, it dives into and cuts through the waves instead of riding over them.

We might anticipate for this that the easiest position for a ship in a heavy sea would be that which she would herself take if left at rest and free from the constraint of engines, helm and sails. For steamers of the type we are now considering (modern steamers of average characteristics), this seems to be generally true. Such a steamer, if left to herself in a seaway will usually fall off until she has the sea abaft the beam, the propeller acting as a drag and holding her stern up. In this position she will roll deeply, but easily, and will drift to leeward, leaving a comparatively smooth wake on the weather beam and quarter, rolling deeply, but in most cases easily, and taking little or no water on board. If oil is used along the weather side and astern, the wake can be converted into an "oil-slick" and all danger of seas breaking on board effectually prevented.

If she rolls dangerously, she may be kept away more, either by setting head sail, by using a drag over the stern, or by turning over the engines just fast enough to give her steerage-way; for it seems to be established also, as the result of experience, that a steamer may safely run with the sea aft or quartering, *provided she runs very slowly.* Clearly this is not "running" in the old sense of that term, according to which a vessel going before the sea was forced to her utmost speed with the idea of keeping ahead of the waves, which were expected to "poop" her if they overtook her. It will be seen from the statements of a large number of shipmasters who have tried the experiment of slowing down or stopping when running before a heavy sea, that

this manœuvre, so far from resulting in the disaster which many seamen would expect from it, had an extraordinary effect in easing the ship and keeping her dry.[1]

The explanation of this seems to be that a ship running at high speed through the water draws a wave after her which follows under her counter and rolls along toward the waist on either side, tending continually to curl over and break on board. This wave is reduced to insignificant proportions in running dead slow.

Another point which enters into the behavior of a vessel going before the sea is that as she rolls and pitches she buries first one bow and then the other, increasing the pressure on the bow so buried. If, now, she is being driven through the water, her head will be forced off, first to one side and then to the other, causing her to yaw badly with a continual tendency to broach to; and this cannot be met by the rudder, because, at the very time the bow is buried, the stern is lifted more or less out of the water, and the rudder loses, for the moment, its steering power. As the stern is lifted, there also comes a racing of the propeller which is in itself a serious danger at high speed. Whether these points be sufficient to entirely explain the fact or not, there seems no question that the dangers connected with running, so far from being increased, are greatly reduced if not altogether removed, by slowing or stopping.

It will of course be understood that in this matter, as in all others connected with Seamanship, due regard must be had for the peculiarities of the individual ship; and that the manœuvre which is safest for a majority of ships may be dangerous for certain ones. Thus a ship whose cargo is of a kind that may shift should not be allowed to roll excessively;—nor should a battleship whose heavy guns are carried high above the center of gravity. The same is true to some extent of sailing ships, whose spars may be endangered by rolling too deeply. For such vessels, a course and speed should be maintained which will keep them reasonably steady, even though this may involve some strain upon the hull and some risk of shipping water. But on whatever course the vessel may be kept, this rule may be regarded as of universal application;—that, other things

[1] See § III of this Chapter for the testimony of shipmasters on this subject.

being equal, *the lower the speed at which she is run, the easier she will be.*

Attention may be called here to an important relation, not always recognized, between a ship and the waves in which she floats. For every ship (in a given condition as to trim, &c.), there is a perfectly definite " rolling period "; a period, that is to say, in which she will make a complete roll, *without regard to whether she is rolling ten degrees or forty.* So, also, in the case of a seaway, there is usually a fairly regular interval of time between wave-crests passing a given point. If the point is a ship in motion. her motion may increase or decrease the interval between the waves so far as she herself is concerned; but this will not change the *regularity* of the interval. If, now, it happens that this interval coincides with that required for the ship to complete a roll, each wave as it passes her will add its rolling impulse to the accumulated effect of those which have preceded it, and the ship will roll more and more deeply until she reaches *the maximum roll of which she is capable.* She will not roll over, if properly designed, because there are forces at work to resist the rolling, and these increase as the depth of roll increases, until the rolling forces and the resisting forces balance. But she will continue to roll to the maximum limit until something is done to break up the synchronism between her period and that of the sea. This can be accomplished, *provided the ship has headway,* by changing the course or the speed or both; thus changing, not the real, but the apparent, period of the waves. By running more nearly into the sea—meeting the waves—the apparent period is shortened; by running more nearly before it, the period is lengthened; but in either case it is *changed* and will no longer agree with the rolling period of the ship. The same effect is produced by a change of speed. If, therefore, it is judged from the violence of the rolling on a given course that the period of the waves is coinciding with that of the ship, the course or speed or both should be changed to break up the synchronism.

The length of the ship, as compared with that of the waves, is also a very important factor in the behavior of the ship, especially when she is running more or less with the waves, or meeting them. It often happens that a small, short ship, in a long sea, will be perfectly comfortable where a larger and longer one makes very bad weather. The small craft climbs up and slides down

the waves, accommodating herself to their slopes, and pitching only as the slope changes; while the longer craft, partially spanning the crests and the hollows of the waves alternately, one end being poised on the crest of one wave while the other end is buried in the adjoining one, may be making very heavy weather. A few years ago a large cruiser in the Philippines was very badly battered by a typhoon, while a small gunboat which passed through the same gale at very nearly the same place, was perfectly comfortable. A Cuban revenue cutter, less than 100 feet long, was caught in one of the heaviest cyclones of recent years some twenty miles south of Cienfuegos and rode it out not only without discomfort but without damage to a light dinghy which she carried rigged out at davits overhanging the side and only eight feet above the water. There are many other similar cases on record. It is no unusual thing to hear that a vessel has foundered in a gale, and that her boats have ridden out the same gale in safety. The great difficulty here is to load the boats and get them clear of the ship. Once clear, they are often much safer than the ship.

If, when a steamer is before the sea or in the trough, it is decided to bring her up to it, bows-on, she should first be slowed until she has barely steerage way, and should then be brought up as gradually as possible. To put the wheel over with considerable speed on and bring her up with a rush—slapping the sea in the face, as it were—would result in serious damage, if not in foundering. After getting her up to it, bows-on, the greatest watchfulness is required, first, to avoid falling off into the trough of the sea, as she will try to do the moment she loses way, and second, to avoid driving into the heavy, breaking seas, which will threaten her now and again. There is reason to believe that many of the phenomenal "tidal waves" reported as having suddenly overwhelmed steamers in mid-ocean have been simply the exceptionally heavy waves which build up from time to time in any long continued gale; and that their destructive power was due to the fact that the vessels were driven into them instead of being allowed to drift before them and ride over them unresistingly. An officer should always be kept at the engine-room telegraphs, in lying to bows-on, and an engineer standing by below, to obey his signals instantly. So long as she heads up to it, the more slowly she turns over the

better. If a heavy sea is seen bearing down upon her, she should be stopped altogether. If she falls off, it will be necessary to increase the speed a little to bring her up, but she must be slowed again as soon as possible.

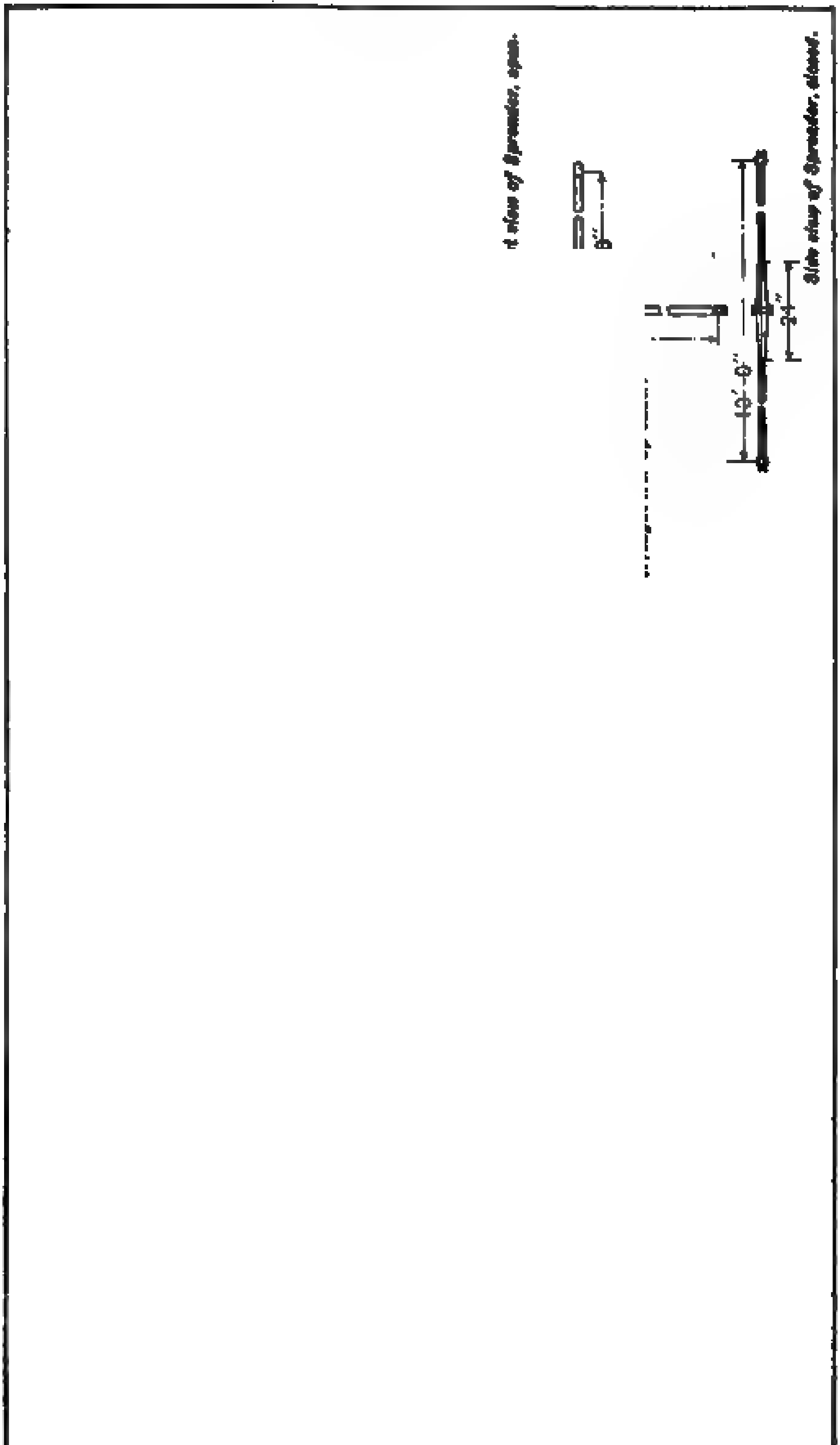
The use of a ***sea-anchor*** is advocated by many writers on Seamanship, and it is commonly assumed that by its use any vessel may be held head to sea and enabled to ride out a gale. No doubt this can be done if the anchor is large enough and strong enough. But considering the importance that is universally attached to this method of riding out a gale, it is surprising how little it seems to have been used and how small is the amount of practical evidence available with regard to it. If used with a modern steamer to keep her head to sea, it acts against the drag of the screw, which, as has been seen, tends to keep her ***stern-on*** to it; and to overcome this it must be very large and very strongly built; otherwise, its effect will be to keep her in the trough of the sea.

With small ships, and especially with sailing ships, it has been tried often and with good results. Such a ship, riding to leeward of a sea-anchor of fair size with an oil bag hauled out to a block on the hawser well clear of the stem, and drifting slowly astern, will ride out almost any gale with safety and comfort. Indeed, as has been said above, this is the ideal position, in very bad weather, *for any vessel which can be made to take and keep it*. But it is doubtful if a large steamer could be made to do this without the use of an anchor too unwieldy to be handled conveniently in a heavy gale. There are certainly few instances recorded of its use with large steamers; and the shipmasters who advocate it for all cases do not claim to have tested it under these conditions.

If, however, the steamer is to be kept *before the sea,* and especially if she is stopped, a sea-anchor may be laid out to windward (and astern) with great advantage, since it will in this case act ***with*** the drag of the screw instead of ***against*** it, helping to keep her more nearly before the sea.

A convenient type of sea-anchor is shown in Plate **136**. It is merely a large drag, floating but well immersed, and resisting motion through the water by reason of the large area which it presents. It is attached to a line from the ship by a span and has a tripping-line from its apex, for capsizing it, to admit of hauling in.

Plate No. 198.



SEA ANCHOR

In cases where a light drag is needed and no sea-anchor is available, a boat may be used, with a hawser made fast to a span from the bow and stern ring bolts, and to a belly band amidships. Or a long spar (or a number of spars lashed together) may be used, also slung by a span. If a topsail or a heavy awning can be added to such an improvised anchor, it will help to break the seas.

There are cases recorded of vessels having been kept head to sea by paying out their chain cables, unbent from the anchors. Where the water is shallow enough for the chains to drag on the bottom, they are especially helpful; in deep water, they have the disadvantage of burying the bow. A good sized manila hawser, paid out *on the bight* both ends being kept on board, makes a very convenient drag—perhaps the most convenient that could be devised. With both ends leading in through the stern chocks, it would be extremely helpful for holding her stern-on, and with one end at the stern and the other at some point near the beam, she could be held with the sea on the quarter. A block on the hawser would admit of reeving a line for hauling oil bags out and in.

Where the depth of water admits, a stream anchor or a good sized kedge may be let go with a long scope of cable, either chain or rope, and allowed to drag on the bottom. In comparatively shoal water, a vessel may ride out almost any gale, *at anchor,* provided she has a sufficient scope of cable. During the Civil War in the United States, scores of vessels lay at anchor off the Atlantic coast, and rode out gale after gale, winter and summer, without a single disaster. Under such circumstances, the longer the scope the better; and *one anchor with two cables on end* is preferable to two anchors, each with half the scope of chain. The engines may be used, but very cautiously, to relieve the strain on the cable if this should be thought too great.

Some years ago a steamer was caught in a very heavy on-shore gale off the coast of South Carolina with her engines disabled. Being in shallow water, she let go both anchors and at once swung head to wind and sea, tailing on to the shore. The anchors dragged slowly but held her head up to the gale and she drifted stern-on to the beach where she lay for twelve hours or more with tremendous seas breaking over her bow, but with her crew and passengers safe at the stern. She ultimately swung around broad-

side-on, and broke up, but this not until long after all hands had been taken off.

In twin-screw ships, the propellers have not as much drag as with single-screws, and such ships can sometimes be held up to the sea without being driven into it dangerously, by turning over the lee screw very slowly. This is often the best way to lay a twin-screw ship to, although there is nothing in the nature of the case to prevent such a ship from riding easily with the sea astern or quartering.

We may sum up what precedes on the various methods of handling a ship in heavy weather, with the statement that the ship will usually be safest and most comfortable when end-on, or nearly end-on, to the sea, and *drifting before it.*

If, by the use of sails, a drag, or any other means, she can be held bows-on, *while being still allowed to drift*, this is probably the best way to lay her to; but if she cannot be held up without being forced into the sea, it will be because of the natural drag of the stern and propeller, and in this case advahtage should be taken of this drag to hold her more or less directly *stern-on*, letting her drift in this way.

Even if the position she takes up in drifting is nearly in the trough of the sea, it will usually be found that she is easier in this position than in any other, but the use of oil, as described below, is especially important in such cases.

If the position which she takes in drifting proves to be one in which she rolls dangerously, then she may run just fast enough to steer, *but no faster*, and so keep the course which is found most comfortable.

§ II. THE USE OF OIL.

The effect of oil in calming a rough sea has been known from the earliest times, but only very recently has advantage been taken of it to any important extent. The very general use that has been made of it in the last few years is due largely to the researches and publications of the Hydrographic Office of the United States Navy Department. Since that Office took the matter up, a great number of shipmasters have experimented with it, and a mass of evidence has been accumulated which leaves no possible doubt with regard to its utility.

Plate No. 187.

Towing against a Sea.

At Anchor
Haul out bag to block on cable.

THE USE OF OIL

The action of the oil is not only to prevent the breaking of waves, but to a considerable extent also to prevent them from forming, and its effect when used on an angry sea is described by all who have tried it as magical. Even in a surf, while it cannot altogether prevent the waves from breaking as they are driven in upon the shoals, it greatly reduces their violence, and will often enable a boat to land when otherwise it would be out of the question.

Almost any kind of oil will give good results, but some kinds are very much better than others. Animal and vegetable oils are best; for example, sperm, porpoise, linseed, olive and cotton seed; and fairly thick and heavy oils are better than lighter ones. Oil of turpentine is probably the best of all. Mineral oils are much less effective, but a very thick sticky oil or one that tends to thicken or congeal in cold weather, may be improved by thinning with petroleum. Soap-suds has a remarkable effect in preventing the formation of waves, but it does not keep them from breaking when formed.

Any method will answer for using the oil which produces a slow and steady flow. A convenient way is to fill the closet bowls with oakum and oil, or to place a can with a tap slightly opened where it will give a slow drip into the bowls and out through the waste-pipes. A still simpler way and one frequently used is to fill a canvas bag, from one to two feet square, with oakum and oil, and punch a number of holes through the canvas with a sail needle. Such a bag may be hung over the side at any point where it is found to give the best result. If there is danger of its being thrown back on board by the sea, its lanyard may be led through an eye-bolt or a shackle in the side. If for any reason a very rapid flow is wanted, a hose may be led through a scupper or over the rail, and the oil poured into it through a funnel—or, in a sudden emergency, the oil may be *thrown* over the side. The quantity used need not exceed a few gallons—four or five at most—even for a large ship riding out a prolonged gale.

The diagrams of Plate 137 show how the oil may be distributed to advantage under various circumstances.[1] To the cases there illustrated, we may add the following:

[1] Adapted from an Essay by Captain Karlowa, of the North German Lloyd S. S. Line.

CROSSING A BAR IN HEAVY WEATHER.

Here the oil is needed for a short time only, but in considerable quantities and on both sides. A convenient way of using it is to trail a hose over the bow or through the hawse pipe on each side and to pour the oil freely through this by means of a funnel.

LOWERING AND HOISTING A BOAT IN HEAVY WEATHER.

A boat is always lowered and hoisted to leeward, with the vessel usually either bow or quarter to the sea. A small quantity of oil slowly poured over the side a short distance forward or abaft the boat (depending upon the way she gets the sea) adds greatly to the ease and safety of handling her and gives her a "slick" in which to come alongside or get clear.

It should be noted that the rate at which the oil spreads is slow in comparison with the speed even of a vessel drifting. Thus a vessel lying with engines stopped can make a "slick" to windward but not to leeward—except, perhaps, very close alongside—because she drifts faster than the oil can spread. So, in running, a vessel can leave a slick astern and to some extent on either hand, but can do nothing to calm the waves ahead of her. She can, therefore, avail herself of the benefits of oil if she is running more or less before the sea, but not at all if steaming into it.

§ III. SOME OPINIONS OF SHIPMASTERS UPON LYING-TO IN MODERN STEAMERS.

The author of the present work has collected the views of forty prominent shipmasters upon the subjects of the preceding pages. Of these, thirty-two strongly advocate either stopping the engines entirely, or turning over dead slow and bringing the sea aft or nearly so. Seven prefer to lie to bows on, but think the other method perfectly safe for most steamers. Three have tried the experiment of stopping the engines, but found the rolling so alarming that they were obliged to bring the sea on the bow. It is an interesting fact that these three were captains of large Atlantic liners.

The following are extracts from a few of the letters received:

Captain Otto Nielsen, S. S. Pennland, writes:

"I have laid-to with engines stopped in a terrible sea whilst in command of the S. S. Switzerland, westward bound, facing for several days a heavy westerly gale and enormous high sea. A heavy sea broke on board carrying away after hatches and companions. As the seas had been breaking over more or less and would continue to do so, filling the 'tween-decks with water, and as it was impossible for anybody to be about decks to repair the damage, I was compelled to stop both engines immediately, at the same time starting both oil tanks going fore and aft on the weather side. In less than a minute I could see the oil spreading up to windward and in less than five minutes it had spread at least 300 feet. The ship kept gradually falling off until she was in the trough of the sea. The heavy seas with breakers would come up to the oil and go under it as if it were a blanket and when they reached the ship it was like a long lazy rolling swell, giving the ship a push, but never a bucket of water coming on board.

Of course the ship rolled considerably but in an easy way, and in fifteen minutes after the engines were stopped the decks were perfectly dry fore and aft."

Captain D. Richardson, S. S. Noranmore, writes:

"I find in the North Atlantic great advantage in lying-to with the quarter to the sea. Put the helm hard up and keep the propeller just revolving to break the sea and prevent the rudder being damaged. Use oil from forward, amidships, and on the quarter. This plan was carried out in the S. S. Baltimore in a hurricane on the 2nd and 3rd of February, 1899, off the Grand Banks when so many steamers were disabled and lost. I escaped with little injury."

Captain H. Doxrud, S. S. Rhynland, writes:

"I prefer to stop engines entirely providing I can run oil out liberally. On the 7th of May, 1898, whilst in command of the American S. S. Pennsylvania, I ran into a hurricane with a tremendous sea. It was impossible without great danger to get along the upper deck, as the seas swept all over her. I was then lying-to, head to sea, and making very bad weather of it. During the height of the storm the engines had to be stopped, the ship fell off with the sea a little abaft the beam and remained so. Oil was used liberally on both sides all the time. The difference in the ship's behavior was simply marvellous. She took little or no water over but was rolling very heavily."

Captain S. W. Watkins, S. S. Montana, writes:

"With my present command I prefer lying-to with the sea right aft, speed reduced and running oil from waste-pipes of W. C.'s, as I find she is much easier that way."

Captain A. R. Mills, S. S. Westernland, writes:

"I prefer to lie to with the engines stopped and the sea quartering. I have tried this several times with different steamers and it worked

beautifully. They rolled a good deal, of course, but with a good oil streak to windward they shipped no water."

The following extracts are taken by permission from a valuable paper, "Notes on Handling Ships," by Captain D. Wilson-Barker, published by the Shipmaster's Society, London:

Captain A. H. Brown, S. S. Hunstanton, writes:

"In December, 1886, being in ballast, I was running before a westerly gale and high sea for Memel. Knowing that port could not be entered, and that my vessel could not steam against such weather, I decided on rounding to when about 50 miles off shore. The helm was put down, but the steamer would not answer it; she came to the wind about every half hour, immediately fell off again into the trough of the sea, and drove to leeward at an alarming rate. After about two hours I determined to try her stern on, and did so with most satisfactory results, for although the engines were going slow *astern* we held our own, rolling ceased, and she lay *steadily* quarter to sea. After a while she paid off to nearly right before the wind, and nothing could be better than her behavior; the helm was kept amidships all the time. So satisfactory was the manœuvre that under similar circumstances I have always adopted it since."

Captain J. G. Groombridge, writing of a spar-deck steamer, 3123 tons gross, 400 H. P., says:

"Off Cape Horn, Bar. dropped 29.60 to 28.80 in. during four hours, the wind increasing to a hurricane, it and the sea abeam, the vessel rolling very heavily and shipping much water, fore and aft. I decided to put her before the wind and stop the engines. She then lay with wind and sea on the quarter, and never shipped a drop of water. After this and two other experiences of like character, let wind and sea be ever so violent, I shall never hesitate to act in a similar way."

Captain Jackson of the S. S. Palamed, writes:

"I have had one experience in a typhoon. I found the ship making very bad weather whilst steaming slowly ahead, so after consideration, I stopped the engines and let her take any position she chose. She gradually fell off until we had the wind about four points on the quarter, and there we lay until the blow was done. We did not take any seas on board from the weather side, the cross swell rolled aboard over the lee side, but there was not the least damage done."

Captain Slessar, of the S. S. Pecheli, writes:

"I was caught between Shanghai and Nagasaki in a very heavy gale and high running sea, the ship at the time in ballast trim. As she was continually falling off I at length decided to let her remain so. She laid with the wind a little on the starboard quarter, the helm amidships, if I remember aright; then the engines *were worked slow astern*, with no appreciable difference as regards ship's position. In this way she lay for 30 hours, riding easily."

The following extracts are taken by permission from letters by shipmasters of high professional standing, published by the Nautical Magazine,[1] as part of a discussion of this subject:

One shipmaster writes:

"The question of riding out a gale with engines stopped is a big one and the answer depends upon the type of vessel and her trim; but this I will say, that on no occasion, when in consequence of break-down of machinery or stoppage of engines from other causes, the vessel in which I have been serving has been allowed to take up her own position, has she shipped any heavy water. Many years ago, in mid-winter, when one of the large Atlantic Liners in which I was serving broke down when homeward bound, during an exceptionally heavy gale, and drifted for more than a week, rolling out gale after gale, the only occasion on which she shipped any heavy water was when an attempt was made to bring her head towards the wind by means of a sail, for in those days the Atlantic Liners had masts and yards and could spread a good deal of canvas. Then she relieved the deck of two boats and a house.

Another shipmaster writes:

"Some few years ago, I was running right before a very high N. W. sea, off Belle Isle, in command of a deeply laden tramp. I never remember either before or since seeing so high a sea running in the Bay of Biscay. When abreast of Belle Isle light, distance seven miles, she pooped a tremendous sea, which washed all our deck gear adrift, and started the after bulkheads of both deck bunkers. I at once came to the conclusion something must be done, and that very quickly, or the ship would founder. I then ordered all hands to lower bridge, all deck openings being battened down, intending to bring her head to sea; I therefore eased the engines to slow, to take the way off her prior to bringing her head to sea. Directly the vessel began to lose her way, the effect was simply magical; she shipped no heavy water at all; so I kept on going easy all night, the vessel making splendid weather of it till dawn, when the storm moderated."

Still another writes:

"On Sunday, Nov. 24th, 9 P. M., very heavy gale and very high sea. Ship scudding dead before the sea. The ship, although a very fine seaboat, kept continually filling her fore well (74 feet in length), chock full from rail to rail.

Before putting my oil bags over, I thought, 'here is a grand chance to try how she acts dead slow.' So I eased the engines to dead slow. The moment she lost her strong headway, the effect was magical. The fore well became nearly dry, only a lipper went over occasionally as it rolled along her side, and the ship was as truly comfortable as she could be wished for."

[1] See an interesting discussion on this subject in the Nautical Magazine for 1895 and 1896.

CHAPTER XIX.

THE HANDLING OF TORPEDO-VESSELS.

§ I.

As preliminary to a discussion of the handling of torpedo-vessels, attention should be called to certain features of the design and construction of such vessels which influence their behavior and which, in many cases, call for altogether different handling from that which would be appropriate for other vessels under similar conditions.

There are several different types of destroyers in the United States Navy, varying from the Decatur type, of 420 tons displacement, designed in 1898, to the type designed in 1916, of approximately 1200 tons displacement, with a horsepower greater than that of the *Connecticut* class of battleships.

The earlier types were coal burners with reciprocating engines. The later types are oil-burners with turbine engines.

While there have been many changes in design between the *Decatur* and the *Allen,* the high forecastle which came in with the *Decatur* class has persisted. The latest projected design has a high forecastle but continues this as a flush upper deck throughout the length of the ship.

The high forecastle of the *Decatur* and later classes plays a very important part in their manœuvring qualities, acting as a permanent jib, which, while helpful in manœuvring under some conditions is a serious handicap under others. It must always be kept in mind and allowed for. Its principal effect is, of course, to make it difficult to bring the vessel up to the wind. This makes it very dangerous to run such a vessel into a small harbor into which the wind is blowing, if it will be necessary to turn her within the harbor in order to get out. Under such conditions the boat will in all likelihood get beam to wind, and, lacking space to gather headway and use the helm, will simply hang broadside to the wind and may drift ashore broadside on. Several narrow escapes are on record resulting from failure to appreciate this feature. In turning with a vessel of this type, it is desirable to turn in such a way as to take advantage of this jib effect instead of having to work against it. The effect of the

wind upon the bow is particularly noticeable and particularly important in going alongside a dock, and failure to make proper allowance has in certain cases resulted in serious disaster.

The facility with which many torpedo-vessels can be handled *when going astern,* especially when the wind or current, or both, are from astern, will in some cases render it advisable to make landings, enter slips, etc., stern first. With gentle sternboard, motion of one screw astern, as described later, will ordinarily pull the stern *toward its own side,* and very delicate control is often possible under these circumstances. Experiments in handling with sternboard will well repay a commanding officer. A special case in which this method of handling is recommended is in running into port with following wind and current, when it is intended to pick up a mooring buoy. Rounding-to under these circumstances will be a long and troublesome operation, especially if the channel be narrow; and under these conditions the bow may be run up to the buoy and held there indefinitely, with stern to wind and tide, by skillful backing of first one engine and then the other.

In handling under sternboard, however, it must be remembered that, while the engines may be safely sent full speed astern when the ship is nearly dead in the water, if she is allowed to gather excessive sternboard there is great danger of carrying away the steering gear. For this reason too much momentum must be avoided when going astern.

The *Decatur* type has what is known as a *flat stern,* the bottom of the boat rising from about the dead flat section in almost a plane surface, so that the draft of the hull itself at the stern is only a few inches. The beam at the stern is much greater than in other types, and the entire above-water after-body is very full in shape. The advantage gained by this form is that the stern keeps very close to the water, since a drop of the sea of a few inches leaves the entire weight of the stern unsupported, and it drops to follow the sea very quickly. In the same way, a rising sea, by rising a few inches over the full-bodied quarter, greatly increases the buoyancy of the after part of the vessel and the stern rises immediately. The general result is that the stern sticks to the water, and racing of propellers and the probability of pooping are reduced to the lowest degree possible with a vessel of the size. There is no after deadwood on these vessels, and in most of them arched tunnels are constructed in the bottom

from just forward of the screws to the stern, which aid the race from the screws in getting clear. The effect of this absence of deadwood is that the stern offers very little resistance to lateral motion through, or rather over, the water, and a very small turning circle results. When the helm is put over, the stern simply slides along on the surface of the water. This results in a very small turning-circle, which, while extremely advantageous from the point of view of handling in confined areas in smooth water, if carried to excess becomes objectionable in a seaway; since the very reasons which make it possible to turn the vessel sharply, also make it impossible to keep her from yawing in rough water. In a heavy following sea, this yawing becomes so great that it is very difficult to steer a steady course, and "broaching-to" may result, with all its attendant dangers. Such a vessel, when a heavy following sea commences to rise under the stern, seems to hold her bow fixed in the water, while her stern is thrown bodily off by the advancing and rising sea as she presents her quarter to it in yawing; with the result, in an extreme case, of bringing her beam to it just in time to receive the breaking crest aboard.

Torpedo-vessels are necessarily of light draft, which gives them less hold on the water than larger ships, so that the effect of the wind is much greater than would be looked for in other types of vessels. With much wind or sea, considerable leeway may be looked for when steering a course, even at very good speed.

Torpedo-vessels are all built long and narrow, in the effort to get high speed from small light hulls. In order to make them light, the factor of safety of the hulls is reduced as much as possible, so that care must be exercised not to strain them. They must be handled carefully, and should never be forced when it is possible to avoid it. Their length and lack of rigidity of hull, together with the ease with which their low hulls are swept by the sea, makes it dangerous to drive them with any speed into a heavy head sea. In handling these craft, therefore, *lee-shores should be as carefully avoided in doubtful weather as they would be in a small sailing-vessel.* This point is emphasized by the fact that no ground tackle has as yet been devised for them which is anything like as efficient as that of other ships; their anchors cannot be trusted to hold them against a moderate wind or current, especially if accompanied by any sea.

The features described above and their effects are modified in other torpedo-vessels according to their shape, etc. Thus in certain classes of destroyers a large after deadwood is found, with the result that they steer well in a seaway, but have a very large turning circle under helm alone. If the flat stern type leans to excess in the direction of ease of smooth-water manœuvring and lack of stability of route in a seaway, these last-named vessels err in the other direction, it being impossible to handle them in narrow waters with helm alone. Another cause operating to produce a large turning circle in this class is that they have their rudders forward of the screws, which arrangement always reduces the efficiency of the rudder.

Screw Action. The effect of screws of different types upon the manœuvring of steamers is very fully discussed in Chapter XI. These effects are more or less modified in torpedo-vessels by the great length of the vessels as compared with the leverage of the screws, the result being that under the most favorable conditions the manœuvring power due to the screws is rather less than in vessels of greater beam as compared with length. The maximum of unfavorable conditions is reached when "in-turning" screws are used in vessels of the destroyer type. It has been explained in Chapter XI that with in-turning screws the tendency to turn the ship which results from the "off-set" of the screws is opposed by the side-wise pressure of the blades, so that these two forces, which with out-turning screws are added to each other, with in-turning screws act against each other, the result being that in any given case it is impossible to say what the combined effect will be. Moreover, since this effect will in all cases be small, it is often overcome and completely masked by the effects, also subject to variations which can not be foreseen, of such factors as wind and sea and current. The situation resulting from these conditions, baffling enough in large ships, is far more so in vessels having the many other peculiarities of the destroyer type.

In vessels of this type having in-turning screws, it is found, as a matter of practical experience, that in perfectly smooth water, with no wind or current, if one engine is turned ahead and the other astern, with equal power, *the ship will not turn.* A preponderance of power on one screw will cause her to turn slowly, but it is impossible to predict to which side this will be. If there

is any wind, she will probably work her stern up into it and hang there. Advantage may often be taken of this to turn without gaining ground to either side. If one screw is stopped and the other turned ahead, the helm being still kept amidships, it is uncertain what the result will be as to turning, but she will in all probability fall off to one side or the other under the influence of outside circumstances such as wind, sea, current, etc. About the only rule which seems to hold under these circumstances (turning with little or no way on the vessel) is that the *backing* of one screw will, in general, draw the stern *to its own side;* the starboard screw to starboard, the port screw to port. But even this rule may fail because of trifling interference due to wind or sea or current.

The behavior described above is what may be expected from in-turning twin-screw vessels at low speed, such as is necessary in handling around a dock. In open water, with plenty of headway, some modifications may result. For instance, with the vessel at good speed, if the helm be thrown hard aport,[1] the turn will be helped at first by sending *the port engine astern;* but the moment the headway drops, it must be *stopped* as it will otherwise delay the turn; and the turn must be finished with the helm and with the starboard engine still going ahead, but with the port screw stopped.

A safe rule to follow in approaching a dock with an in-turning screw vessel is to assume that if the engine away from the dock be backed (as would be done with out-turning screws) *the bow of the boat will be thrown into the dock.* Therefore in going alongside, come in on a slight angle with the dock and then stop the headway *by backing the engine next the dock.* This will stop her headway, and straighten her out along the dock at the same time. In leaving a dock, if the engine furthest from the dock be backed, it will (unless prevented by wind or current) draw her stern neatly away from the dock. In this one point the in-turning screw is useful.

Torpedo-vessels are all very light craft with very powerful machinery. As a consequence, they may be stopped very short, even when at full speed, and may, when necessary, be handled with high-engine power even in close waters. *As a result of this fact, and of the fascination of handling such high powers, nearly every torpedo-boat officer passes through a stage in his*

1. right rudder.

development when he thinks that this particular form of rashness shows the high quality of his seamanship and nerve. When that phase of development comes, the effort should be made to *get over it as soon as possible;* for while it may impress the ignorant, it will be regarded as childish folly by men of experience. A good torpedo-boat officer is one who uses the powers at his command daringly *when necessary,* but who does not invite disaster in order to show off. It happens from time to time that an engine will not follow the signal, through fault of either personnel or material; and if this happens when the officer in charge is seeking to display his nerve, the result is a smashed bow or some worse accident, resulting not from an effort to perform some required important service, but merely from a desire to " show off." It is not believed that this paragraph will entirely prevent young men from thinking they know more about this point than older and more experienced officers, but it is hoped it will help them to get through the troublesome period without unnecessary delay.

In this connection a caution must be given in regard to the difference between the action of different types of boats and their engines, in handling. Suppose we assume two similar boats, of the same power and speed, but that we have in boat "A" this power attained by engines which turn with a comparatively low number of revolutions for their maximum power, developing it through length of stroke, with large diameter and pitch of the propellers, whereas in " B " we have an engine of shorter stroke and much greater number of revolutions, using a screw of smaller diameter and pitch. It is probably safe to say that "slow" in both boats means about the same number of revolutions, but the effect produced on the boat as the result of an "ahead slow" signal will evidently be very different; since a given number of revolutions will, in "A," apply far more power than it will in "B." The result is that a "slow" signal, which might just control "B" properly, would cause "A" to jump ahead or astern to a degree that might result in danger.

Similarly, the effect of an attempt to use engines to stop or reduce headway, will be very different in the two classes. If, while going ahead, the engines of an "A" boat be reversed, she will stop as though she had struck a stone wall, whereas the "B"' boat would advance much further and be a much longer time in stopping. These are very real conditions, and lack of familiarity

with them has in the past caused damage to certain boats. An officer who is familiar with class "A" boats only, knowing the ease with which their headway can be checked, may well get into serious trouble if he assumes the existence of like qualities in one of the "B" class.

Similarly, an officer who is familiar with "B" class only, who starts to handle an "A," around a dock, is in danger of jumping his boat into something lying ahead or astern before he realizes the enormous effect produced by a couple of turns of an engine in the "A" class.

This brings us directly to the use of the engines in warping or springing around docks. In all of these vessels the warping chocks, cleats, etc., are very light. If the fact be kept in mind that the horse-power of the latest destroyers is greater than that of the *Connecticut,* and that the hull of the former is at the limit of lightness, it will at once be realized that chocks, cleats and lines can only be used against the engines with extreme caution. This caution applies not only to the fittings of the vessel itself, but to the lines by which she is to be handled. Nothing smaller than a 5-inch line should be trusted for a spring, and with the largest class of destroyers a 6-inch is none too strong. This matter is especially important as applying to the A class of boats above referred to.

Another important difference in the handling of different types has to do with the question of quick turning, with small tactical diameter, under the rudder alone. In the flat-stern boats, with no after deadwood, when the helm is put over, the stern simply slips around over the surface of the water with no vertical submerged surface to retard its swing, and the result is a very short turn, executed very quickly. In boats of this type, at fifteen to twenty knots speed, the tactical diameter under helm alone is something less than three ship's lengths, which is remarkably small. In the *Normand* type of boats, which have a large deadwood aft, the turning circle is very large indeed; so large in fact that M. Normand builds all his boats with bow rudders, a feature that has unfortunately been omitted from similar boats in this country.

When we consider smooth-water work alone, the small turning circle is a very valuable feature, but when one of the flat-stern boats gets into a seaway, it is found to have its disadvantages

also. As has already been explained, the very fact which makes the small turning circle possible, namely, that there is nothing aft to keep the stern from swinging, leads to dangerous yawing in a seaway, especially with a sea abaft the beam. There is nothing in the afterbody to hold the vessel steady and give her the quality sometimes referred to as "stability of route." A following sea lifts the stern and throws it to one side without hindrance. As a result, steering a course is very difficult, and the yawing which results not only leads to danger of broaching-to, as already pointed out, but makes it difficult to determine what course has actually been "made good," thus introducing danger of serious errors in navigation.

In the boats with a large after deadwood, and with large turning circles, the stability of route in a seaway is excellent.

We thus see that quick turning and stability of route in a seaway are opposite qualities; if either of these is very highly developed, it must be at the expense of the other; and in designing the effort must be to attain a proper mean; a mean, however, which it is almost impossible to define in specifications.

To turn in a limited space it is well to use the engines in brief spurts of high speed, being careful not to allow the ship to gather much headway. Under some conditions the turn can be made very short by giving the vessel sternboard and then throwing all propellers ahead against a hard-over rudder, the screw current being very effective here, especially with triple screws.

At Sea. The performance of a torpedo-vessel at sea is as peculiar as are her actions under other conditions. In the first place, the boat is so light in proportion to her size that she acts among the waves very much as does a floating boar Rolling is heavy, and yet there is surprisingly little jerk at the end of the roll, as a result of which there is much less tendency to throw things about than would naturally be anticipated.

With a head sea, or sea forward of the beam, the rolling is more uneasy than when the sea is further aft. With a sea abeam or abaft it, the boats seem to rise and fall without excessive motion, exactly as a cork would, and under such conditions ship comparatively little water.

With their quick period, a short, steep sea is more trying than any other. It is probable that they would make excellent weather

of a long storm sea, provided the combers could be kept from coming on board.

Excessive pitching is rare, but racing of engines and pounding of flat sterns are common, and are experienced to a far greater extent when steaming into a head sea than under any other conditions.

In steaming into a head sea, vessels of this type ship more water than under any other conditions. This is of course the case with other vessels, but not to the same degree, the low freeboard of the torpedo-vessel making them poor sea-boats in this respect. The great danger in shipping large masses of water is that it may go down the fire-room ventilators, and either fill the fire-rooms or smash the blowers and render the boat helpless by depriving her of forced draft. There is also danger of having the hatch-covers torn off and the hatches thus left unprotected.

Of course hatches may and must be more or less securely battened down under such conditions, but the fire-room ventilators must be left partly open, as they furnish the sole supply of air to the fires. Their cowls should be turned away from the sea, and the most exposed of them should be closed.

In addition to the troubles already mentioned as to be expected in steaming into a head sea, a point is soon reached where the light bow-plating begins to give way under the pounding of the seas. Small boats have had their bows twisted badly, and destroyers have had bow-plating bent and smashed in, sufficiently to fill the forward compartments. Forward air ports are a source of danger, and should be closed with metal covers as soon as a head sea begins to get up. Forecastle hatches require careful attention, as do the anchors and all other gear carried on the bow.

It will be seen, therefore, that bucking a head sea is the most trying effort that these vessels can be called upon to make, and these troubles may be met even at comparatively low speeds. The boat may be damaged forward, racing may cripple the engines, and pounding of the stern may easily start leaks aft. This may all take place, too, before reaching a sufficiently high speed to enable the ship to make headway over the ground.

From the preceding remarks, it will be seen that every precaution should be taken to keep out of any situation where bucking a head sea may become necessary. Keep away from lee shores. Practical experience shows that the commander of a torpedo-

boat should bear this warning in mind to fully as great an extent as would an officer in command of a sailing-vessel. Its importance cannot be too strongly urged.

And bearing on this point, it must be noted that torpedo-vessels, even at high speeds, sometimes make an astonishing amount of leeway; even more, in some cases, than would a sailing-vessel. Whether this is actual leeway, or the result of other causes such as yawing, bad steering, etc., cannot be definitely stated, but it may exist, and must be carefully guarded against.

Another point of interest is that, in any torpedo-vessel in a heavy sea, there is always more or less *bending* of the hull. While the degree to which this will occur varies with the structural strength of the individual vessels, it will become apparent to the eye at times in almost any vessel. It comes mainly, of course, when the sea is such as to hang the vessel first by the ends with the center unsupported, and then the reverse. If excessive, it should be checked by changing the angle between the course of the ship and that of the sea. In two of the destroyers which made the trip to Manila in the winter of 1903-1904, this bending was sufficient to start small cracks in the deck-plating in several places. Hard patches were put over the cracks, extending beyond their ends, and no further trouble was experienced. These cracks are most apt to start at points where the plates are securely riveted to thwartships water-tight bulkheads, and so have no chance of play. So long as they do not become excessive in extent, so long as the hull does not start to leak below the water-line, and so long as the deck stringers and sheer strakes remain intact, the structural strength of the boat may generally be considered as unaffected.

With an increasing sea, therefore, if ahead, slow down as necessary. If compelled to heave-to, it is believed by a majority of officers that the only safe way to do it is with the sea aft. In turning away from the sea to do this, follow the course laid down for any other ship. With the sea following, adjust the speed for comfort, and also the angle between sea and keel; and, as soon as excessive yawing begins, tow a hawser astern to keep her stern from being thrown from side to side. This will do much to keep her from being thrown around so far that the seas will sweep her decks, a thing which might easily happen otherwise. It is believed that craft of this type can run in this way in a very heavy sea.

If necessary to heave-to, use any form of sea anchor. It would probably be best to secure this on one quarter so that the sea will be quartering and not directly astern.

In lying-to in a long or moderately long sea, it may be found that the best position is with the wind and sea a very little abaft the beam; in other words, in the position which the ship will take herself if allowed to drift. If she pounds when in this position, keep the engines turning over; but in a long sea there will probably not be much pounding. This position, with the sea nearly abeam, is an extremely easy one if the sea is long enough; nothing is strained, and no water except spray will come aboard. The spray may be kept down by the use of oil along the weather rail.

In other words, the best direction from which to take the sea is between the beam and the quarter. The exact position must be determined in each case by experiment, and will depend upon the character of the sea, force of the wind, type of boat, condition of loading, etc.

In connection with this question of lying-to stern to sea, rather than bow, it may be noted that, owing to the difficulty of keeping the high bow up to the wind, the speed necessary to enable her to be kept head to sea will in all probability be great enough to cause the bow to be smashed by the seas, and it is doubtful whether even a sea anchor from ahead would hold her up to it safely.

The use of oil is most strongly advocated as soon as the sea reaches any serious height, and it is often useful even in moderate weather to secure comfort for the crew by keeping the decks dry. The methods regularly laid down for the use of oil are applicable to torpedo-vessels, and it will be noted that such use is far easier and more efficient with a following sea than with one from ahead. The importance of oil for these vessels cannot be overestimated, and every boat should have the necessary apparatus at hand whenever she goes to sea. The readiest method of using it is by attaching the bag to the towed hawser or to the sea anchor line in such a way that it may be hauled aboard and refilled.

Dangers of Loading. In loading a boat with unusual weights, the local weakness of the hull and the general structural lack of rigidity must be constantly borne in mind, to avoid concentrating masses in one locality. If a deck load of coal is to be carried,

pack it in bags and spread these in one tier around the decks rather than concentrate it in convenient corners. In rigging booms or derricks to handle weights, always rest the heel on a plank long enough to rest on several beams, as otherwise the boom may cave in or punch through the deck. In landing a heavy weight such as a spare propeller, always lay down planks enough under it to distribute the weight over a number of frames. Be careful not to land such weights directly over engines, etc., that are attached to the under side of the decks, such as fire-room blowers; since a very slight sagging of the deck there will throw the engine parts out of line.

Handling Small Boats. In general it is best to remember that the ship herself is a small boat, and that she can be much more readily handled herself than can one of her pulling boats.

It has been found that, if a buoy be dropped overboard, and the helm be put hard over immediately, the speed of the engines remaining unchanged, when the ship's head has swung through a full circle she will be very near the buoy (allowance being made for current). This method of recovering a man who has fallen overboard is recommended rather than the lowering of a boat. In putting the helm over, it is important not to swing the stern of the ship onto the man.

In lowering and hoisting boats the usual general rules apply. With the flat-stern boats, however, there is grave danger of getting the boat under the stern while it is clear of the water, and then having the stern come down on top of the boat, or of getting the boat drawn into the screw tunnels, especially if the ship has sternboard or if her screws have been recently backing. Most torpedo-vessels have small guards (they should all have them) around the side, and these are apt to roll down on the rail of a boat and either capsize or smash her. This danger can usually be overcome by having men on deck hold long oars or other spars vertically against the side, with the lower ends far enough down to keep the boat from getting under them.

Remember that, on all torpedo-vessels, the boat davits are very weak.

In picking up torpedoes it is wise to go alongside of them to leeward, if the state of the sea permits, as will usually be the case. While the general rule of making a lee with the ship for a boat or other object which it is desired to pick up holds for torpedo-vessels in a seaway, as well as for other ships, it must

be remembered that the wind has no effect upon a torpedo floating the water, whereas it has a great effect upon a vessel lying dead in the water. Therefore, if the boat is brought up to windward of the torpedo, she will very often drift over it, and there is perhaps danger of its getting in the shafts or screws. It is therefore better, if the conditions will permit, to come alongside to leeward of the torpedo.

Towing. The greatest difficulty to be anticipated in towing arises from the local weakness of the light hulls. It is very difficult to find anything strong enough for securing the lines. Conning towers and torpedo-tube circles are about the only things that can be relied upon, and on these there will be found so many points of chafe that some trouble will be encountered.

Some vessels have eyes fitted outboard, on stem and stern, for making fast tow-lines, the eyes being secured to steel bands which stretch along on both sides for a distance and are riveted up to a number of frames. These do very well for moderately heavy work, but probably would not stand in heavy weather. Lines must be shackled into them, and, when once secured, are very hard to cast adrift. See Chapter XXI.

Close-Order Steaming in Flotilla. While a discussion as to the value of close-order formation belongs to tactics and not to seamanship, it will not be out of place to give here directions as to the handling of torpedo-vessels in such formations, it being taken for granted that (as all the leading naval nations have found to be the case) some form of close formation is essential. The general preference seems to be for the formation known as the wedge, which is a double echelon at close distance, with the angles of bearing of the flanks drawn aft at a very oblique angle to the keel of the leader.

For thoroughly satisfactory wedge woık the boats of the flotilla must:

1. Be practically alike in their general characteristics.

2. Have smooth sides with no projections except the guards.

3. Have fore and aft guards parallel to the water-line and at the point of maximum beam. These should be carried well forward and aft; should have vertical shoe pieces at regular intervals above them, tapering from no thickness at the rail up to the full width of the guard, so that the guards

of neighboring boats will not catch above or below each other. They must also be wide enough to keep the hulls of the boats apart. They should be of wood, steel faced, and so constructed that in case of accident they will tear off instead of tearing holes in the side of the boat.

4. Have propellers that do not extend out at the side beyond the hull at that point.

5. Have deck connections to the throttles so that the speed may be regulated from the deck.

In smooth water, with such torpedo-vessels, it has been found easier to go alongside another vessel in motion than to go alongside a dock, because, as the only thing that can cause damage is the *difference in motion between the two* and not the actual motion over the ground, it is a fact that both boats can keep good steerage way, and thus be readily handled. One boat must steer a steady course at regular speed. The second should then come up on her quarter, bring her bow abreast of the after conning tower of the leader, assume the same speed as the leader, and then very slowly close in with the helm. It will be found that, as she closes in, the wash from the leader's screw will tend to keep her off against her own helm and will so cushion her that the impact will be very light. This is very easy of accomplishment after a little practice, under favorable conditions.

As soon as the bow of one boat is alongside the quarter of the other, it will be found that the water pressure against the outer bow of the former will press her up against her mate, throwing her own stern slightly out; and that when once this position has been reached it is only with considerable difficulty that the rear boat can get away.

To show the facility with which this may be done, it may be stated that in some cases it has been the custom, when the flotilla was at sea, and when the services of the medical officer of the flotilla were required on some boat other than the one to which he was attached, to thus run the bow of one boat up against the quarter of the other and permit him to come aboard, without interfering with the progress of the flotilla.

If now a third boat takes a similar position on the other quarter of the leader, it will be found that the inward pressure of the two will tend to steady the leader on her course, and handling the group becomes an easy matter. The boats are so close together that relative differences in speed are quickly detected and

easily corrected, and the pressure holding the boats together tends strongly to equalize the speeds. The leading boat may be given full helm, and the whole group turned with a very reasonable flotilla tactical diameter. In making such a turn, the leading boat, after giving notice to the others, simply puts her helm over; the special care which the others have to exercise is to keep up against her. To do this, if the turn is to be with starboard helm, for instance, the right flank boat uses starboard helm[2] also, but not enough to hamper the swing of the leader's stern. The port boat, however, will at first need a little port helm[1] to keep the leader's stern from swinging away from her; and after that, very little helm at all. In such a group formation it may be said that, within reasonable limits, the helm and engines of the leader control the course and speed not only of herself, but of her two mates. The great precaution to be observed in such a formation is to avoid any sudden and rank movement that is not expected by the other boats. Such movements are not necessary, as the several commanding officers are within conversational distance of one another.

If two more boats are added, to make a five-boat wedge, they take up similar positions on the outward flanks of the second and third boats. Far more care is necessary in this case, however, since the second and third boats have their sterns free to swing in, and if the flank boats use their helms carelessly and exert too much inward pressure on their mates, these mates will have their bows canted out, the rush of water will get between the bows and the leader, and they will shoot out to one side and break up the formation. Subject to this caution, the procedure is as with three boats only.

In breaking up the wedge, the best method is for the rear boats to slacken speed and drop clear, one after the other, although they may be also sent clear by a rank shear with the helm. Of course, in this method also, the rear boats should win clear first.

Assuming that a close formation is necessary to enable orders to be passed to the group by word of mouth, it would seem that *the safest way is to have the boats touching; for two ships already touching cannot collide, and, in case of an unexpected bump, the nearer together the boats are when they commence to acquire relative momentum towards each other, the lighter will be the bump.* Also, the wedge, as described, ensures that such a bump

1. right rudder. 2. left rudder.

shall occur at the most oblique angle possible. It has been found by actual experience that boats actually touching are far less apt to injure one another than when an effort is made to maintain them in formation a few yards apart.

Another word of caution is necessary. One boat should never try to take close position on another by coming up from nearly astern of her. Get well out clear of the race of the leader and then edge in as described. The other course is very dangerous.

When the weather is bad, of course, the wedge must open out as circumstances render necessary, but it has been found practicable in a much heavier seaway than one would believe possible.

In all close-order work the rule must be to make haste slowly when inexperienced, and never relax from the utmost care and vigilance.

Speaking Large Vessels. The greatest care should be taken in speaking large vessels when they are underway or anchored in a tideway. The tendency is to call a torpedo-vessel up abreast of the forward bridge of a large ship when the latter is in motion. This should never be done. It has been forbidden in some squadrons by special order. The speaking boat should come up on the quarter of the ship just as she would in taking wedge position on another boat, and conversation should be carried on with the quarter deck or after bridge of the ship. This leaves the boat free to swing her stern towards the ship if necessary, in order to increase distance, which could not be done if she were further forward. When further forward, also, the boat gets into such a position that the indraft of the ship's screws tends to draw her in. When a boat is running parallel to and near a big ship, in a position well forward in relation to the latter, the boat is dwarfed into insignificance and her commanding officer loses his power to fully realize his exact situation. He cannot correctly observe the steadiness of course of the big ship, changes in her speed, etc., and should she slow for any reason, he will be under her bow before he knows it. In repeated instances it has been proved that, in such a position, he is apt to close in without realizing it until he is so close that, if he puts his helm over, his stern will take against the ship's side and a smash will follow.

This is but one example of the wisdom of a good general torpedo-boat rule: *"Keep your stern clear to swing, no matter what happens."*

Another advantage of the quartering position is that, in case

of trouble, "full speed astern" on both engines will clear you in an instant.

Peculiarities of Navigation aboard Torpedo-Vessels.

Although not properly belonging to the subject of seamanship, a few cautions as to the navigation of torpedo-vessels may not be amiss, especially as they are to be found in no other publication.

As already mentioned, leeway, real or apparent, must be carefully watched.

It is impossible to so compensate the compasses for heeling error that there will not be great oscillations of the card in a seaway, so that it must never be taken for granted that a correct course has been steered.

The compass conditions are often bad, and compasses very often lack directive force, and are consequently inaccurate, although a careful "swing" in smooth water may not show material deviation.

It is especially hard aboard these vessels to eliminate changes due to the presence of movable iron near the compass.

In many cases, the magnetic conditions of the ship have been known to change suddenly and often, due to causes not yet fully comprehended. The deviation table of to-day may be badly out to-morrow.

The eye is so near the water in these craft, that lights, etc., are sighted at much less distances than would ordinarily be expected.

The motion is often so excessive that it is exceedingly difficult to use any navigational instruments. Pelorus, azimuth circle, parallel rulers, etc., may all easily become useless because the navigator has all he can do to hold on and keep himself secure from being thrown from side to side.

In using a sextant the boat often rises and falls so much and so fast as to keep the dip changing rapidly. This same motion also gives you a sight at one moment of the real horizon, and at the next, merely of the top of some near-by wave. Sight taking under such conditions is very inaccurate.

In addition to all this, in any but good weather, all positions from which navigation can be carried on are apt to be deluged with spray, or even by green water, which effectually puts a stop to ordinary methods of work.

The use of the hand-lead is very difficult. Only a low height can be secured for the leadsman, and steerage way speed is so

high that he cannot get soundings in any except the shoalest water. If there is much motion on the boat at the same time, the lead becomes well nigh useless. While the lead must be constantly used, in accordance with the Navy Regulations, it cannot be relied upon.

Chronometers, too, are apt to lose their steadiness on torpedo-vessels, as a result of vibration, excessive motion, etc.

To summarize, it may justly be said that practically all the methods of navigation employed on board large vessels become very unreliable on board torpedo-vessels, except under the most favorable conditions. The demand that such a vessel makes upon the judgment, alertness and carefulness of an officer can hardly be overestimated.

§ II. SUBMARINE BOATS.

1. Any vessel that can manœuver totally submerged, as well as on the surface, is called a *Submarine*. The submarine here treated is in reality a submerging or diving torpedo-boat, and its function is to discharge torpedoes.

Submarines are divided into types depending upon the method used to force them under the water while making way through it. In this country the **Holland** and **Lake** types (named from their inventors) are distinguished by differences of this character. The Holland boat makes use of a diving rudder only, while the Lake boat has hydroplanes as well.

2. A circular section is the strongest form known, to withstand either internal or external pressures. It is used in the construction of submarines, because of the very great external pressure to which they are subjected. The frames are circular, usually between 15 and 20 inches apart, and the plating is put on in fore and aft strakes. The boat when finished has the shape of a huge torpedo. Within, and forming the inner bottom, are the **ballast tanks**. These tanks are used in destroying the buoyancy of the boat, and are tested to strength equal to nearly that of the outer hull. At either end of the boat are small **trimming tanks**, used to bring the boat to a certain angle of trim. Sometimes small emergency tanks are fitted which allow for quickly blowing a small quantity of water, and are of use in balancing.

Propulsion **on the surface** is obtained by means of gas engines; **submerged**, by means of electric motors, the electricity being provided by a storage battery. The battery may be charged by the

engines (the motors then acting as dynamos) or from an outside source. Gasoline tanks are provided for stowage of gasoline.

To submerge the boat, water is admitted to the ballast tanks until only a few hundred pounds of positive buoyancy remain. The boat can then be easily forced under water when making headway, by the methods mentioned as peculiar to different types.

When it is desired to rid the tanks of water it may be done in three ways:

1. Blowing with air.
2. Pumping with main power pumps.
3. Pumping by hand.

Air flasks are provided, capable of being charged with compressed air to a pressure of 2500 pounds or over. This air can be blown into any tank at any desired pressure through air lines fitted with proper stop-valves. When air pressure is admitted into a tank (at its highest point) and the flooding valves (at the lowest point) are left open, the water in the tank will be blown out, provided the internal air pressure is greater than the external water pressure due to the "head" of water.

All tanks are fitted with vents to allow for flooding, for the release of air pressure after a tank has been blown, and to allow a suction when the tanks are pumped out.

The main-power pumps are run either through suitable gearing or by clutches from the main shaft, and will pump against a great pressure. The water-lines are so arranged that all tanks can be opened up to the main pump.

The hand-pumps are operated entirely by hand, and would afford the final method used to free the tanks of water, when the air and electricity had failed. They can be connected to any tank.

The volume of air contained within the boats is usually sufficient to last from 5 to 6 hours before becoming vitiated. The renewal of air is provided for by the main pump taking its suction from the bilges or lower portion of the boats, and discharging outboard, while fresh air is admitted to the interior from the compressed air banks until normal atmospheric pressure is obtained. The general practice is to start the renewal of air after being with closed hatches for 4 hours. After this time, 2 inches by barometer is removed every 4 hours, and air admitted from the air banks to bring the pressure back to normal. The compressed air contained in the banks is considered sufficient to sus-

tain life for about three or four days in the ordinary type of submarine. Below is a formula for determining the number of days the contained compressed air in the air banks of a submarine will sustain life:

X = Number of days life is sustained before symptoms of distress occur.
a = Air pressure in banks, per square inch.
b = Cubical contents of banks in cubic feet.
c = Number of men in crew.

$$X=\frac{11ab}{36000c}$$

NOTE.—This formula was computed assuming that one man uses .8 cubic feet of oxygen per hour; that there is 20 per cent by volume of oxygen in the air; and that symptoms of distress occur when the oxygen has been reduced to 12 per cent by volume.

Torpedo tubes are fitted in the boats, the number depending on the size and displacement of the submarine; these are in a nest forward; all point dead ahead, and all are stationary.

The boats are fitted with two sets of rudders; one vertical, one horizontal. The vertical rudder is used for steering on the surface, by either hand or electrical control, and the horizontal rudder for regulating the depth, by hand only.

Two **periscopes** are fitted in all submarines; one "dead ahead" periscope for the helmsman, and one "all-around" periscope for the commanding officer. The latest type of "all around" periscope has a fixed eye-piece and the image is always erect, that part of the periscope containing the upper prism revolving through 360° by means of a small 2½ horse-power electric motor. An azimuth circle is provided with the periscope for taking bearings and there is also some form of range-finder and torpedo director attached. The periscope is an instrument to convey the reflection of objects on the surface to those working the boat below. It consists of a long vertical tube, with prisms at either end, and suitable lenses. This tube reaches some 15 to 18 feet above the deck, running through the hull, with the eye-piece within the submarine. With the boat submerged to a depth of 15 feet, the top of the tube containing the upper prism is some 3 or 4 feet above the surface of the water, and as the two prisms give a double reflection, the operator within the boat sees objects on the surface as though his eye were at the position of the upper prism; that is, some 3 or 4 feet above the surface. These peri-

scopes are of use only when the boat is submerged to such a depth that the upper end of the tube is still above the water, a depth which manifestly cannot exceed 18 or 19 feet.

Conning towers are fitted to all submarines, and provided with eye-ports from which navigating is done in rough weather. The tower stands about 6 feet above the deck. The helmsman controlling the vertical rudders steers from this station when submerged, using compass and dead-ahead periscope.

Cooking is done upon electric stoves, taking current from the storage batteries.

When totally submerged, the courses are steered with ordinary ship's magnetic compasses, but as these act rather sluggishly at times, the new gyroscopic compass is being developed for submarine use.

Every submarine is fitted with some form of cruising bridge for surface work in rough weather. This can be dismantled and struck below in a very short time.

A suitable **submarine signal apparatus** is installed on all vessels, making signalling possible between boats for a maximum distance of 7 or 8 miles. (See Chapter VI.)

Handling of Submarine Boats. There are three conditions under which submarines usually operate; viz., the *"light"* or cruising condition, the *"awash"* condition, and the *"submerged"* condition.

In the "light" or cruising condition, the main ballast, auxiliary ballast, adjusting and midship tanks, should be kept free of water, and the water in the bilges should be kept as low as possible, in order to prevent the dangerous tendency to dive when there is free water in the main ballast or midship tanks, or in the bilges.

The forward and after trimming tanks are used to give the boat the most efficient trim for surface running. This trim is usually about 2° or 3° down by the stern, but it varies slightly with different types of boats. Except in cases where a main hatch trunk is fitted, the main hatch should always be kept closed when underway. The torpedo hatch is also closed and should never be opened when underway. The conning-tower hatch and all ventilators are kept open except in very rough weather, when every opening in the boat should be sealed except one ventilator which supplies air for the engines. This ventilator is so fitted that it can be lowered from inside the boat. In manœuvring

around docks or landings, the boat is handled under the electric motors; and as it carries a good deal of way through the water even after the motors are stopped and reversed, care should be taken not to have too much speed on the boat when making docks or landings. The tail of a submarine is very delicate, owing to the diving and steering rudders, and this should always be borne in mind when manœuvring in close quarters.

At half speed the steering effect of the rudders is very slight, especially when submerged; and where the maximum steering effect is desired, full speed should be used. In backing, single-screw boats are very uncertain, the direction in which the tail will swing apparently following no known law, except that it has been frequently noticed that if the motors are reversed while the tail is swinging, then when the boat gathers stern board, the tail will continue to swing in same direction. When there is a wind, a submarine boat can always be depended upon to back with tail into it.

Submarine boats are not affected by a short choppy sea; they plough through with little or no motion. At sea, in the ocean swell, they are extremely tender and often very wet owing to their comparatively small reserve of buoyancy. It is a common mistake for towing vessels to under-estimate the tonnage of submarines, and to endeavor to make too high a speed, thus frequently parting the lines and at other times dragging the boats through heavy seas without giving them a chance to ride.

To stop the screw of a submarine boat when submerged, is to take off practically all the steering effect; consequently, when in the proximity of shipping or in narrow channels, care should be taken to have motors turning over full speed when maximum steering effect is desired.

In submarines of early type, the gasoline engines cannot be reversed; so that all close manœuvring, such as that around docks, in picking up tows or towlines, etc., is done under the motors.

Towing. For extended towing operations, a 7-inch manilla hawser, well protected by chafing gear, and fitted with a pelican hook at the bow of the boat being towed, makes a good towline. One end of this line carries a pelican hook engaging the wire or chain towing pendant or bridle (or both), on the submarine, while the other end is secured on the towing vessel. The towline should be as long as possible. In all cases of towing submarines,

the greatest care should be exercised in selecting the gear to be used, because of the difficulty in running lines and in handling them on the limited deck space of a submarine in rough weather, if a hawser or pendant carries away. If a preventer bridle is used, it is secured to the forward body-cleats and well protected from chafing on the nose of the boat. If one submarine tows another, a heavy wire-towing bridle fitted on the after-body cleats will give the best results. The hawser is shackled into a ring at the end of the bridle, well forward of the propellers, and the whole rig is protected from chafing by wooden strips secured along the hog-back.

For anchoring, a small 450 pound mushroom anchor and 50 fathoms of 5/8-inch steel wire cable are supplied. The anchor is hoisted by electric motors and housed in a compartment in the keel forward, the bottom of the anchor being flush with the keel when hoisted. The anchor is handled entirely from inside the boat. A special cable-cutter is fitted, whereby the cable may be cut if necessary while in the submerged condition.

Submerged. The general methods of trimming down and running submerged are the same in principle for all classes of boats, the later ones being fitted with better safety devices, stronger tanks, etc. The method is about as follows: On deck, take down portable bridge, life lines and stanchions, all portable navigating gear, life buoys, ensign, pennant, and all tools which may have been used about the deck. Drop the ventilators, close upper ventilating caps, and send cowls below. See torpedo and main hatches closed, with clamps on, and close outboard fuel-tank vent. See that the doors on the various compartments in the superstructure and conning tower fairwater are closed. Other openings, such as those for engine-room bell-pulls, hand-steering gear, running-light cables, etc., are closed with caps. Inside the boat, the bilges are pumped, all valves in the engine-room are secured, the principal ones being the muffler valves and the engine circulating water valves. The conning tower is now closed, and a small relief valve in the top of this tower is opened. The boat is first leveled by clinometer with the forward or after trimming tanks; the midship and adjusting tanks are next flooded, and then the main ballast tanks. This should sink the boat until the deck is just under water. In the *Plunger* type, the vents and kingstons on the main ballast tanks are now closed on account of that tank being a weak one. In the later boats,

the main ballast vents are closed and the kingstons are kept open, except where they are fitted to open out against the water pressure, in which case the water pressure outside holds them closed. Any air pressure in the main ballast tanks in excess of the water pressure outside, will open the valves and blow out the water. The automatic blow device can be set at any desired depth, so that the main ballast tanks will be blown automatically when that depth is reached. This device is not fitted in the submarines of the *Plunger* type, as their tanks are structurally unable to stand the pressure at depths over 25 feet.

The auxiliary tank is next flooded until the water-line strikes the eyeports in the conning tower. This will leave the boat at about 600 pounds buoyancy, and she is now ready for running submerged. The best trim for submerged running is different for the different classes of submarines; but with about 600 pounds buoyancy and a trim of 2½° to 3° down by the head, the boat will handle very well at any depth. The motors are now started, and the diving rudder is handled to make the boat dive to any depth and to run at that depth.

The depth is automatically registered on a hydrostatic gauge which is graduated in feet and tenths. The clinometer here becomes an important factor in steering in the vertical plane, bearing the same relation to the horizontal rudders that the compass bears to the vertical rudders. A good maxim which submarine officers follow, is "16 or 60," meaning either to run at a depth of 16 feet when the periscope is showing several feet above water, or at such a depth that all shipping on the surface is necessarily cleared. This is a good safety rule to follow, as it minimizes the chance of collision. This chance of collision is inherent in submarine boats, particularly when rising after a dive; and for this reason the time consumed in showing the periscope at the surface when rising from the 60-foot level should be as short as possible.

The torpedo tubes can be used to trim the boat. The forward fuel tanks can also be filled with salt water, but this latter is not good practice, as it causes engine troubles due to water in fuel. A record is kept of the quantity of water in each tank, so that the submarine can be trimmed for diving, without stopping, by filling all the tanks in the order given above, and tending the boat with the diving helm.

To run *awash* under the engines, a special type ventilator is provided, which can be closed from inside the boat. All preparations are made as before except that the "awash" ventilator is kept up. All tanks are filled as before except the auxiliary, which should be kept empty. The air for the engines is supplied through the ventilator, and a fuel-tank vent inside of the boat is kept open. The diving rudder is tended very carefully to prevent the boat diving, and a watch is kept on the ventilator, which can be closed instantly by a flat valve, should any water enter.

To *dive* from the awash condition, the engines are stopped, the motors started, the ventilator closed, and the auxiliary tank is flooded to adjust buoyancy.

To balance the boat at any desired depth (usually at a depth which will permit the periscope to be used), the buoyancy is decreased to 0, and very small quantities of water are pumped into or out of the adjusting tank by means of the adjusting pump, until the boat is stationary or balanced at the desired depth.

The tactical diameter when in the light condition is about 250 yards, and when submerged is about 150 yards.

An azimuth circle is so fitted to the auxiliary or navigating periscope that bearings can be taken for plotting positions.

Accidents; Causes and Prevention.

The main causes which have contributed to submarine accidents are the following:

1. Gasoline explosions.
2. Hydrogen explosions.
3. Water entering boat.

(1) **Gasoline explosions** have been the cause of several serious accidents, all due to gasoline leaking into the boat through bad connections and combining with air in the mixture of from 10 to 20 parts vaporized gasoline to 100 parts air, and by the ignition of this explosive mixture by a spark. This accumulation of gasoline fumes is not a defect peculiar to submarine boats, but may happen in any confined space where gasoline is kept. By keeping all gasoline tanks and lines and pumps tight, by proper ventilation, and by keeping open lights out of the boats, accidents from this cause can be prevented. When loading gasoline, no smoking or open lights should be allowed in the vicinity; and when the slightest trace of gasoline fumes are present in the

boat, no electric switches, which might give a spark, should be thrown, until the boat has been ventilated thoroughly and the leak stopped.

Members of crews have frequently been overcome by gasoline fumes. The fumes act as an anæsthetic, and they cannot readily be detected until symptoms of distress occur. Great care should therefore be taken to keep the ventilation always perfect. Especial care should be observed in running by the engines on the surface, with a following wind, that exhaust gases from the engine are not being blown down open hatches or suction ventilators.

(2) **Hydrogen Explosions.** A great many minor explosions have occurred from this cause and some loss of life has been occasioned. An electric storage battery of the lead type, as commonly used in submarines, gives off hydrogen gas freely while the battery is being charged, especially toward the end of a charge. In cases where explosions have occurred, it has been found that the hydrogen gas has banked up underneath the battery deck, through improper ventilation, and, owing to the difference in potential between certain plates and portions of "electrolyte-soaked" partitions, a spark has resulted which served to ignite the explosive mixture of hydrogen and oxygen. Accidents of this nature may be prevented by keeping the ventilating fans running at full speed while charging the batteries, and by keeping the battery clean. No foreign matter should be allowed to get into or around the cells. A sure preventive for "electrolyte-soaked" partitions is to neutralize them with soda solution, bi-weekly, and to keep the cell partitions clean and dry at all times. There is no record of any hydrogen explosion occurring on battery discharge, nearly all having taken place near or at the finish of a charge.

(3) **Water Entering Boat.** This is the principal cause of submarine accidents. Not only will water entering in considerable quantity destroy what little buoyancy the boat has, but salt water combining with the sulphuric acid of the battery, will cause the evolution of chlorine gas, which is fatal when breathed.

One possible consequence of a boat's acquiring negative buoyancy through the entry of water, is to cause the boat to descend below its designed depth (generally 200 feet) where it will succumb to the outside crushing pressure.

There are two principal ways in which water may enter a boat: through an open or improperly closed hatch; or through a hole in the hull of the boat due to collision or other accident.

The first of the causes has been responsible for a great many serious accidents, and can be traced to lack of care or judgment. Such accidents can be avoided by keeping the main deck hatches closed and clamped at all times when underway, by carefully closing and securing all other hatches before diving, and by handling the diving rudder when in surface trim, so that the boat is habitually kept 2° or 3° up by the head. A hatch found to be improperly closed after submerging should never be touched until the boat is brought to surface, except in case of extreme emergency. A hatch should never, under any circumstances, be opened while in "submerged" trim. The order for flooding the tanks should never be given until all hatches and outboard ventilator connections are properly closed and inspected.

The second cause above mentioned has also been the cause of many accidents. Several collisions have occurred to boats when submerged, but the majority of such accidents have happened to boats while in surface trim. Great care should be taken before diving to accurately ascertain the position and movement of all shipping in the vicinity, and due precautions exercised to avoid such shipping on rising to the surface.

Means of Escape from Sunken Boat. There have been several means suggested for escape from a sunken boat unable to rise, such as escape through air locks in communication with the sea; escape through torpedo tubes; escape through hatches with air or oxygen helmet on. Some of these devices are promising, but none of them at the date of present writing (1910) can be regarded as having demonstrated their trustworthiness.

CHAPTER XX.

KEEPING STATIONS AND MANŒUVRING IN SQUADRON.

It is proposed here to discuss in rather general terms some of the difficulties connected with work in squadron from the point of view of seamanship—not at all from that of tactics. We may regard tactics as prescribing, in a very definite way, certain things which must be done; while seamanship deals, in a much less definite way, with the manner of doing them. The two subjects necessarily overlap each other throughout a considerable field and within this field it is impossible to discuss one of them without touching upon the other. This is the excuse for such comment as is here included upon tactical formations and manœuvers.

All work of ships in squadron is designed as a preparation for battle, but it may be questioned whether sufficient consideration is always given to the difficulties which, in time of battle, will be added to those which are connected with station-keeping and manœuvring at other times. The smoke from the guns and the funnels of ships ahead—all of these ships being under forced draft—will obscure the view from the conning tower in all directions, but especially ahead. The ship next ahead will be seen only a part of the time; the leader of the column probably not at all. And the use of instruments for keeping position will be altogether impracticable.

In ordinary cruising and manœuvring the conditions are much better; the next ahead can be seen at all times, the leader occasionally; and sextants, stadimeters and range-finders are always available for measuring distances. It is questionable, however, to what extent advantage should be taken of these conditions. Certainly a constant effort should be made to train the eye in judging distance both by day and by night—the last without the aid of lights. And it would seem desirable to recognize the fact that only under very exceptional circumstances, such as will rarely exist in battle, can a column of vessels keep their distances from the leader.

Whatever method is used for estimating distance, it will usually be found easier to keep position than to regain it after it has been lost. The moment a tendency is recognized to close up or drop back, the speed should be changed enough, and only enough, to check the tendency. This is better than to wait until the error is so great as to call for a more radical change, which, if prolonged even a very little more than necessary, throws the position out in the other direction.

A caution is called for here. It has already been remarked that a column of ships cannot keep distance from the leader. It seems probable that, in battle, each ship will be reduced to the necessity of keeping distance from the next ahead; and that there will often be a good deal of uncertainty even about this. There will be many times, however, when it is practicable to judge whether the next ahead is or is not approximately in position with reference to her own next ahead. Thus by watching as many ships ahead as can be seen, whether one or two or more, it will often be possible to discriminate between a real and an apparent fault in position and to avoid the vexation of closing up on the next ahead only to find her a moment later dropping back because she has herself been ahead of position.

In spite of all that can be done, a ship will at times get quite badly out of distance. It may be that her revolutions are not quite true to standard, or that she has been badly steered, or that the vessels ahead have changed their speed. When distance has been lost from this last cause, caution must be used in closing, as the other ships may at any time resume standard speed.

Here it may be remarked that *more than half the troubles in station-keeping come from irregularity in the speed and steering of the guide,* and that no amount of trouble should be thought too great to keep these uniform. Good steering can be insured by careful training of the helmsmen, and there are revolution-counters on the market which admit of keeping the speed absolutely steady. These instruments are indispensable for work in squadron. When their use becomes universal, a large part of the drudgery of squadron cruising will be eliminated. Unfortunately, they lack at present one feature which would make them perfect. They do not record on the bridge. This would not be important if the officer of the deck could always remember how many revolutions he had ordered, but there are few officers who

can trust their memory to serve them perfectly on this point. A good plan for meeting this difficulty is to have a dial on the bridge near the revolution indicator, marked with numbers for the revolutions, and with a pointer which can be moved each time that a change is made. The habit of setting up the pointer for every change is quickly acquired, and the dial shows at a glance the number of revolutions being made.

While a perfectly uniform speed is more important on the part of the guide than on that of other ships, it is of immense importance to every vessel of the fleet, both for her own comfort and for that of all the vessels associated with her. It is rather surprising how little attention is usually given to acquiring this habit. As a rule, if ships keep their positions reasonably well, very little thought is given to the methods by which they accomplish this result, and a ship which is incessantly ranging up and dropping back *a little*—without getting seriously out of position—suffers nothing by comparison with one which steams steadily hour after hour. Yet the difference between the two is very great, especially in the consumption of coal and in the demand upon the fire-room and engine-room force. It is worth while to give great attention to this point and to *require* the closest possible approach to perfect steadiness on the part of the officer of the deck and the engineer's force. An excellent way to develop this is by steaming in line. Here errors in *speed* manifest themselves at once and yet they inconvenience no one but the offender. But for good results here, as in other cases, the steadiness of the guide must be beyond suspicion.

Under conditions as they exist at present, some variation in speed must be anticipated, and it is very important for every ship of the column to have timely notice of a change made by the ships ahead. The speed-cones as at present used give information of large changes only. The rules for their use could easily be modified to admit of showing changes of a few turns. But any system of signalling by shapes hoisted at a yard-arm is crude and unreliable and in battle would probably break down altogether. It would not be difficult to devise an electrically controlled system for showing in a sheltered position at the stern the number of revolutions which the ship is making, or, perhaps more simply, the deviation on one side or the other from the number which is for the moment prescribed, whether this be

"standard," "half" or "slow." Whatever system is used, the signal for a change should, when practicable, be shown before the change is made.

Attention has been called to the importance of judging distance without the use of instruments. The clearness with which details can be seen on the ships ahead is a great help here. At certain distances, for example, the name on the stern of the other ship can just be read. It will almost always be possible to select two objects on the other ship which can be brought in range (vertically) for the correct distance, provided the observer always stands at a fixed point. A little pitching may seem to throw this out, but with practice the mean bearing can be recognized. Even at night, if the weather is reasonably clear, this plan is helpful, the spars and funnels of a ship 400 yards away being plainly visible with good binoculars.

It is sometimes practicable to use a mark on our own ship as a means of determining when we are at standard distance from the next ahead, the observer standing always at a fixed point and bringing this mark into coincidence with the water-line or some other well-defined mark on the other vessel. The objection to this is that such a mark would probably not be available in action and is thus worse than useless as a guide at other times. It may be possible, however, to fix a line on something which is always available. An officer looking through a slit in the conning tower, for example, might be guided by the angle subtended by the width of this slit—either vertically or horizontally—his eye being at a fixed point from which this angle just takes in the height of a funnel or the width of a bridge on the ship ahead.

It is important to recognize the effect of *steering,* upon the speed of the ship. A poor helmsman may make it impossible for any officer to keep position. Not only does the ship in steering wildly range over a greater distance than is right, but the "drag" of the rudder holds her back and reduces her speed very materially. It is worth while to give great attention to training the helmsman, insisting not only that a steady course shall be kept, but that this shall be kept with the least possible amount of helm.

It is a common error for beginners to make too frequent and too radical changes of speed as a result of the failure to allow for the interval which necessarily elapses between the signal for

increasing or reducing the revolutions and the actual change of speed and position to be produced by the change in revolutions. It is realized that a large ship holds her way for a long time after the engines are stopped, and that she does not gather way, if at rest, until an appreciable time after the engines are started; but it is not always realized that exactly the same delay must be allowed for in the response to a change of a few turns when the ship is already making way. Thus the beginner, impatient to regain position, and seeing no effect from his signal to add or subtract one or two revolutions, is tempted to call for two or three more; and when, finally, the ship begins to forge ahead or to drop back, his inclination is to let this go on until he is nearly or quite in position, forgetting that the effect of the change in revolutions of his engines will continue to affect the speed of his ship long after the engines have resumed their standard speed. This leads, of course, to almost endless changes in the revolutions and keeps the ship perpetually ranging ahead of position and dropping back astern of it.

Assuming that a ship has dropped astern of position, say a hundred yards, and wishes to regain her place. The first thing to be done is to steady her, and this will not usually call for more than one or two additional urns. Having steadied her, it is well to regain position slowly and if possible to avoid overrunning. Suppose that five revolutions corresponds to one knot. This means that five revolutions per minute will give 2000 yards in an hour. One revolution will thus give 400 yards an hour, or 100 yards in 15 minutes. If, therefore, we add one *to the revolutions which hold her steady,* we may expect to regain position in 15 minutes. If we wish to reduce the time to five minutes, we must add not one turn, but three. We shall not be actually in position at the end of the five minutes, for it will take a perceptible time to pick up the extra speed; but the interval for continuing the extra revolutions will be five minutes, since it will take approximately the same time to run off the extra momentum that it took to pick it up, and the ship should, theoretically, settle into place with the speed which will just keep her there.

Similar considerations govern the reverse operation of dropping back when we find ourselves ahead of position.

In all changes of speed, and indeed at all times when working in squadron, it is not only good "comradeship" but good seaman-

ship, to give all possible consideration to the next astern. It may be difficult for him to run into you, as is often said, but this is no reason for trying to make it easy for him to do so. If the next ahead comes dropping back suddenly upon you, and the next astern is rather closer than he should be, there is no harm in sheering out a little until all hands have time to adjust themselves. And in the simpler case where you are merely called upon to open out for regaining your own position, it is well to do this very slowly, and, if permitted by squadron regulations, to give some signal of your intention to reduce your revolutions, even though you are not coming to "half speed." If you find yourself running up on your leader, you should of course sheer out onto his quarter until he draws away or you drop back.

It is an axiom of tactics that in column a ship is better ahead of position than astern of it. This is for the reason that by running more or less ahead she does not, as a rule, subject any other ship to inconvenience. The next ahead will not usually attempt to get out of the way, and the next astern is under no obligation to follow up. On the other hand, a ship falling materially behind her station crowds back the next astern and inconveniences all ships in rear.

It should be noted, however, that if too much emphasis is placed upon this axiom, there may be a tendency for all ships to close unduly, each on the next ahead, and this may result in congestion throughout the column or a considerable part of it; and while there is comparatively little danger in such congestion so long as a steady course is steered, the danger becomes very serious if the column changes course by more than a few points. If a signal for such a change is hoisted while a number of ships are crowding up on each other, it may be presumed that every ship will try to drop back, thus producing more or less confusion; but whether they attempt this or not, the difficulties of the turn will be much increased.

It is doubtless correct for a vessel which is ahead of position when the signal for a change of course goes up, to try to get into position before the turning point is reached, *but there is no excuse for the disposition frequently manifested to drop back, whether in position or not, to the maximum distance tolerated by tactical regulations.* If dropping back legitimately, it is very important to pick up standard speed—not in revolutions alone, but

in actual speed made good—in time to make the turn with standard speed.

In compound formations there is especial reason for insisting that the individual columns shall not be lengthened out unduly, because the rear of a column which is taking up more than its share of sea-room will crowd the head of the next column when the fleet passes into simple formation. In compound formations, therefore, we may place more emphasis upon our rule that it is better to be ahead of station than astern of it. And here, too, as there are fewer ships in the individual column, the results of congestion are less serious.

In spite of all precautions, interference will occasionally arise between the rear of one subdivision of the fleet and the head of the next one, in passing from one formation to another, and it is well to prescribe rules as to who shall give way in such a situation, and how. A convenient rule is to require the rear vessel of a leading section, when she finds herself so far astern of position as to embarrass the leader of the next section, to give way to the side of safety; letting the leader of the other division swing into his proper place, and continuing on herself, more or less outside the formation, until she finds a chance to work into place.

In running at night without lights, not only can the ship ahead be seen—though perhaps only very dimly—but her wake is likely to show up with more or less phosphorescence. The difficulties of this situation are less than is sometimes supposed. All must be ready for switching on the navigation lights upon the approach of other vessels, and for manœuvring to keep clear as required by law—except, of course, in time of war.

In a Fog.

Running in a fog has been much simplified by the adoption of "position-buoys." It is found well to keep the buoy of the ship ahead a little on one bow and nearly abreast of the stem. If each ship keeps an after search-light trained upon her own buoy at night, the situation is still farther improved. The search-light shows the buoy if it is "watching" and shows approximately where it should be, if it tows under for awhile. Moreover, the search-light itself can be made out for from 500 to 1000 yards

through a very dense fog. Search-lights are useful by day as well as by night, and should be used at all times in a fog.

It is important to keep well closed up in a fog. If a ship loses touch, it is difficult to regain it.

Unless in case of an emergency, only small changes in course should be made in a fog. If the course is to be changed as much as four points, it is better to make two changes of two points each, allowing time between for all ships to get straightened out.

If danger of collision threatens with a ship outside the fleet, it must never be forgotten that the ships of the fleet are to be considered in any manœuver that is made for keeping clear. It is as indefensible in law as in seamanship to foul a ship of the fleet in keeping clear of an outsider. The ships astern may be relied upon to help keep clear as soon as they are notified by signal, but the signals provided for this emergency are far from satisfactory. In case of backing the engines, the International Signal of three blasts must of course be given instantly; but with the other signals that are always sounding in a fog it may be doubted whether this will be recognized as promptly as is desirable. In any event, the caution here given, to remember your own ships as well as the stranger, cannot be amiss.

See page 356.

Although the subject of avoiding collision in a fog is fully treated in another chapter, attention may here be called to the difference between the case in which one ship strikes another on the broadside, and that in which the two ships scrape alongside. The importance of this in connection with ships in squadron lies in the fact that all the ships are, in general, headed in the same direction, so that if one of them stops without turning very much, the next astern, coming up, if she cannot avoid touching, can usually manage to scrape alongside rather than to strike a direct blow. It might perhaps be argued from this that if a ship in squadron finds it suddenly necessary to go *full speed astern* to clear a stranger, she should try to avoid turning more than is necessary. The next astern, coming up, has thus the maximum chance of avoiding collision altogether or of striking a glancing rather than a cutting blow.

The question of speed in a fog is very fully discussed in Chapter XII.

Special sound signals are used for manœuvring in a fog. Those at present established are crude and unsatisfactory. It is thought that submarine signals may sooner or later be made useful here.

It is very important to have a good lookout at the bow and to provide efficient means of communication with the bridge. This lookout should be able to see the vessel ahead at almost all times.

Breakdown.

A vessel which breaks down, hauls out of the column at once and should be very prompt in giving notice to the ships astern. Rules are laid down as to the side for hauling out, and breakdown signals are established.

An accident to the steering gear, if the helm is well over to one side, may make it necessary or advisable to haul out on the wrong side, in which case speed may be increased. The engines will, of course, be used for steering, and if the helm is not too far over to the wrong side it will be easy to swing against it by giving full speed to the off screw and so to haul out according to rule; but if the situation calls for slowing materially on the inner screw, with some delay and uncertainty in getting clear, it is better to keep up the speed and haul out on the other side.

In case the helm is jammed not far from amidships, it should be practicable to keep in position by the screws and so avoid showing the breakdown signal; but if there is any doubt about this it is well to fall out and avoid the danger of trouble.

It is very important to have everything ready for shifting quickly from steam- to hand-steering gear, or, if the accident does not call for throwing out the steam gear, then to shift from one steering-station to another, without nervousness or confusion. Capable men should be stationed in the steering engine-room at all times ready to meet any emergency, and the detail of men for the hand-steering gear should be considered quite as important as the life-boat crew. The lines of communication from the bridge to the various steering-stations should be perfected, and kept always in working order. Finally, frequent drills should make it a matter of simple routine to meet any emergency connected with the steering.

Man Overboard.

Rules are prescribed for this as a tactical manœuver, and signals are provided for notifying the fleet. If the man goes over from the ship ahead of you, you should be able to see him as you run up towards him. By stopping at once, and backing if it seems advisable to do so, you should be able to bring him fairly close alongside and to toss a buoy or a line close to him, being very careful not to hit him. It must be remembered that the *suction* of a screw continues for sometime after the screw is stopped, so that if you are going to run beyond the man you must take care not to let him get near the screw until its wash has subsided. It is a pretty manœuver to bring the man alongside and pick him up with the ship, but unless the ship is practically dead in the water the wash alongside may be embarrassing, and if he goes down he may come up under the bottom. The life-boat will, of course, be ready and can be lowered very near him, and it is not well to take any chances that the man will keep afloat long enough for you to pick him up in any except the quickest and surest way, which will usually be by means of a boat.

Keeping Position in Line.

The most important requirement for keeping position in line is to be absolutely sure about the *course* of the guide. A slight error in this not only leads the ship which is in error to close or open distance without understanding why, but misleads her also as to her bearing. It is helpful to have conspicuous marks establishing a thwartship line *on the guide,* by which other ships may know, not only that they have her abeam, but that they are also abeam of her.

The usual way of keeping bearing is by an alidade or pelorus, which is commonly placed at the end of the bridge and at a considerable distance from the compass.

The indications of such an instrument must of course be constantly checked by reference to the compass, which calls for frequent calling from one observer to another. This is often annoying and may be done away with to a great extent by the use of permanent marks from the compass outboard on each side, establishing a beam line which can be watched by an observer standing at the compass, where he is also near the instrument for signalling changes of speed to the engine-room.

If out of bearing, it is better to be astern than ahead, because when the signal comes to form column it is easy to drop into place by easing the helm and slightly increasing speed.

If a ship which is in position as regards both bearing and distance forges ahead of the line or drops astern of it, she changes not only her bearing, but her distance; the distance becoming too great in either case—that is to say, whether she is ahead or astern of the line. Yet the remedy is merely to change speed, without working in or out with reference to the guide. If a ship, finding herself a little out of position as regards both bearing and distance, attempts to correct these two elements by changing two variables simultaneously—closing in toward the guide, for example, at the same time that she drops back toward the proper bearing—it is impossible to foresee just how she will come out. It is much better, assuming that the total error is not very great, to correct one element at a time, and to begin by getting on the proper bearing, after which it is not difficult to close in or open out by a small change of course and speed. It should not be necessary to change the course more than one-eighth of a point, or at most one-quarter of a point, and tables can be prepared to indicate the change of speed which will hold the vessel steady on her bearing as she heads in or out by this angle. The use of a definite angle here, with the definite change of speed indicated by a table, removes the problem from the realm of guess-work to that of rules; although here, as in all other cases of handling a ship, the rules must always be illuminated by judgment.

It should be observed that any change of distance in line calls for an *increase* of speed, whether it is a matter of closing-in toward the guide or of opening-out from her.

Attention has already been called to the value of steaming in line as a matter of training for steaming at unvarying speed.

On an Echelon Line of Bearing.

For keeping position in echelon, it is even more important than in line abreast, to be sure of the exact course which the guide is steering. It is helpful, if practicable, to have marks on one's own ship, fixing the line of bearing, which will almost always be either two, four, or six points on the bow. If it is not practicable to establish permanent lines from the compass fixing these bearings, the reliance will be upon an alidade or upon direct compass

bearings. The essential point is to so place the observer that he may—always under the general direction of the officer of the deck—watch the bearing and distance and regulate these by a touch, from time to time, of the helm or the revolutions.

If open slits are used in the conning tower, the sides of these, or light colored marks painted on them—the observer's position being fixed—give a convenient line when conning from this point, if nothing more satisfactory is available outside.

Here, as in the case of "Line Abreast," it is well, if a little out of position, to correct the bearing first, and then the distance, thus using only one variable at a time. There is this difference to be noted between echelon and line abreast as regards a change of distance. It has been explained that in line abreast, any change of distance on the guide calls for an increase of speed, whether to close in or open out. In echelon, to close in toward the advanced flank calls for an increase of speed (to hold the bearing steady) and for a greater increase than when in line. But to *open out* in echelon, while keeping the bearing steady, *calls for a reduction in speed.* To work off toward the withdrawn flank without reducing speed would throw us ahead and more or less across the bow of the vessel next toward the withdrawn flank. The importance of this point increases as the sharpness of the line of bearing increases; that is to say, as the echelon departs more and more widely from line abreast and approaches more and more closely to column. When the withdrawn flank is dropped back eight points—forming column—all change of distance becomes entirely a matter of change in speed.

To Change Course in Succession in Column, Turning Eight Points or Less.

One of the most important difficulties connected with the manœuvring of ships in squadron arises from the uncertainty which inevitably exists at any given time with regard to the tactical diameter of any individual ship under the conditions of trim and of weather existing at the moment.

Turning trials are often made so hurriedly and under such unfavorable conditions, as to be of little value at the best; and even when they are made with every care, in a smooth sea and with little wind, they give results which are standard only for similar conditions, and which will vary widely with variations in draft and trim, and in wind and sea.

It should be added that the methods which are in use for determining turning circles and other tactical data are crude and unsatisfactory and it is greatly to be desired that some more scientific method should be devised and put into effect under rules which will not only permit, but require, the accumulation of complete tactical information with regard, at least, to every man-of-war which is ever expected to manœuver in company with other ships.

When all has been done in this direction which can be done, and absolutely exact information acquired, the fact will still remain that the tactical diameter of a ship when trimming by the stern will be greater than when she is on an even keel, and much greater than when she happens to be trimming by the head. Similarly the diameter of a ship which at a given time is trimming by the stern will be materially greater when she is turning up into a fresh breeze than when she is turning away from it. The effect of these and similar variations of condition makes it impossible to say of any ship except in a very general, and often a very misleading, sense, that her tactical diameter is a fixed number of yards for a fixed speed *and a fixed helm angle,* and then demand that the ship shall under all conditions, turn in a circle of this diameter, using a standard helm angle prescribed as the result of trials made with one particular set of conditions.

For a given standard circle—which is what is desired in manœuvers—the helm angle must of necessity be varied from time to time within certain limits, and it is the judgment shown in this variation which makes the difference between success and failure in squadron work.

In making a turn, the leader of the column should be scrupulously careful to use the same helm angle at all times, to put the helm over to this angle in the same interval of time, to ease the helm and reverse it always at the same point of the turn. It is particularly objectionable for the leader to swing past the new course and then come back to it. And the leader should make no change in revolutions during the turn, unless to avoid danger.

The other ships of the column must adapt their circles to the standard thus established by the leader, their problem being to follow around in his wake, preserving the formation as accurately as practicable.

To put the helm over at the right instant and by just the right amount calls for good judgment, and, it would almost seem, for a special instinct. Many officers believe that the difficulty here is best met by noting the instant when the next ahead begins to turn, and adding to this a time-interval calculated beforehand for speed and distance. This seems reasonable, but is not usually found satisfactory in practice. The bearing of the next ahead, or of the second ahead, should be helpful, but this again is found to fail in practice. Perhaps the most satisfactory guide, when it is available, is the path of the ship ahead as marked out by the broad sweep of the wake which she leaves in turning. This starts with a pronounced "kick" toward the off side, where the stern has swung over at the beginning of the turn, and continues as a broad curving arc of disturbed water one side of which marks the path of the stem, the other that of the stern. Practice will make it possible to judge with fair accuracy how far the bow of the following ship should be allowed to enter this wake before the helm is put over, but it must not be forgotten that a fresh breeze blowing across will carry the wake to leeward, and that at night the wake cannot always be distinguished. Moreover, it is at the best, only a guide for turning in the wake of the next ahead, and she may have turned very wide of the leader.

There is no question that the officers who are most successful in this manœuver rely upon the general "look" of things ahead rather than upon any rules which could be formulated for the help of others;—in other words, they more or less unconsciously sum up a number of factors and are guided by the balance of all rather than by any one alone.

A ship well down toward the rear of the column cannot govern herself directly by the leader. She has, however, a good view of the ships ahead, all of which, except the one which has last turned, may be assumed to have corrected any errors made in turning, and to be now following in the leader's wake. Carrying back the line formed by these ships she should be able to judge fairly well how her next ahead is coming out, and to determine whether to turn outside or inside or to follow around as exactly as she can. The difficulty here is far greater by night than by day, and is enormously increased when lights are screened.

It is important to watch the steering after the next ahead begins to turn, *and to take care that the ship is held on her compass course and not allowed to swing off, following the "kick" made by the stern of the ship ahead.* It is helpful here to glance at the ships astern, which are still, of course, preserving the old direction, thus getting a line by which to make sure that your helmsman is not swinging off in spite of good intentions.

It is better to start the turn a little early rather than at all too late. If the bow is pushed too far across the wake of the ships ahead, it catches the current from their screws and is thrown off still more, with the result that a small initial error is greatly magnified. A ship which turns *outside* must accept the situation and straighten out on a course parallel to the column and outside of it. To attempt to work into position across the bow of the next astern while the latter is turning would involve danger of being rammed. It will be necessary, after having turned outside, to increase speed a little, thus making up for the larger circle traversed. A ship which finds herself turning *a little* inside could correct the error by easing her helm and reducing speed slightly, waiting for this until the turn has progressed to a point where the condition of affairs can be made out with certainty; but most officers think it unwise to tolerate this, if only for the reason that it is likely to encourage the altogether unpardonable practice of turning decidedly inside and then easing the helm, merely to avoid the embarrassment of judging when and where to turn properly; or the equally unpardonable practice of "cutting corners" to make up distance.

A ship which has turned inside will usually have to reduce speed more or less to drop into her position, but must resume standard in time to avoid hampering the next astern.

The time for easing the helm and reversing it to meet the ship on her new course will vary with different ships. It is generally found well to begin easing at about two points from the course, bringing the helm to amidships with one point left to go, and then to reverse it as much and as fast as is found necessary to meet her without swinging past the course. It is especially important for the *leader* to be absolutely consistent in this matter.

Each ship before turning should note carefully what her new compass course is to be.

Finally, attention may be called to the importance of being always as nearly as possible in position, as regards both bearing and distance, before beginning to turn. To be outside or inside of the point where the leader has put the helm over means an outside or an inside turn—if we assume that the helm used is that which duplicates the turn of the leader. A still more important point is that the ship should be *steady on her proper course* when the time comes to put the helm over. *If she is off her course or if she is swinging, a variable and uncertain factor is introduced into the turn.* It is important also that the speed should be uniform and standard. If a ship is closing up or dropping back as she approaches the turning point, even though standard speed be ordered at the last moment, she will continue to gain or lose distance throughout the turn.

It is not necessary to point out the exceptional embarrassment which may result from being very close to the next ahead and on her inner quarter when she begins to turn. This situation may arise from the next ahead being out of position, in which case it emphasizes two of the rules which have been laid down above; first, that it is better to be ahead of position than astern, since by being ahead you embarrass nobody but yourself, and second that it is good seamanship as well as good comradeship to avoid embarrassing your next astern. If, on the other hand, it is a real error of position on your own part, it emphasizes the caution already given not to overwork the first of these two rules by making a practice of being ahead of position.

Turning More Than Eight Points.

In a turn of more than eight points it is very dangerous to turn inside. A ship which finds herself in this position should reduce speed in the early part of the turn to avoid running up on the next ahead, whom she will presently find swinging in across her bow as the column doubles back toward its original line. The best that she can do is to keep turning, at reduced speed, and with *hard-over* helm,[1] abreast her proper place in the column, but always inside of it. There will be a temptation to work back into place by easing the helm, but this will check her swing and she can never pick it up again. The result is that if she gets into place momentarily, it will be only to cut across the curve on which the other ships are turning, and, worst of all, to receive a kick

1. full rudder.

from the screw current of the ships ahead on her inner bow, throwing her still further out and more or less across the stem of the following ship, which, swinging as she will be under hard-over helm, is practically powerless to do anything toward keeping clear of a ship in such a position.

The only thing to do, then, is to turn on a circle parallel to that of the column, but with smaller radius. This means a sharper turn and calls for more than standard turning helm and possibly for stopping the inner screw. Here, as in the other abnormal situations, due notice should be given by the cones or otherwise, of all changes of speed. The next astern can, in case of danger, help to keep clear of a ship which is distinctly inside of her, by easing her helm.

A ship turning *outside* the proper path is safe but needs a material increase of speed to keep abreast of position. The danger of attempting to work into place in the column is even greater than in an eight-point turn, so there is nothing to do but to keep up as well as possible and be ready to resume position after the turn is completed.

The difficulties and dangers of a "counter-march" are so many and its utility is so slight that in some fleets it has been given up, its place being taken, when a change of 16 points is to be made, by two 8-point turns.

Turning Simultaneously.

To turn simultaneously through 8 or 16 points is a test of many points in the work of the squadron; since any error in position, speed, or tactical diameter is brought out very strikingly. In one respect, the apparent result may be misleading, since the guide now changes (usually) and it may happen that ships which were exactly in position with the old guide and which have turned perfectly, are altogether out when the turn is completed, as a result of faults on the part of the new guide.

As soon as signal is made for this or any other manœuver which involves a change of guide, each ship should try to get her distance and bearing from the new guide so that she may know where she is likely to find herself at the end of the manœuver, and what will be necessary for getting into position. By watching the guide as the end of the first eight points is approached and completed, much can be learned about the way the ships are

turning with reference to each other, and this is a good time also to get the distance, if practicable. The adjoining ships on either hand should also be watched, as intervals are sometimes closed rather unaccountably in a turn of this kind, and ships run up dangerously close without clear evidence as to which one is at fault. (See remarks below as to reasons for variations of speed in the turning of different ships.)

As the new course is approached, certain allowances must be made (unless prohibited by tactical regulations) to perfect the alignment on the new guide.

It is a fact often noted in fleet manœuvers where vessels of different type are associated, that some ships lose much more speed than others in turning. There are several reasons for this difference. With ships of different length, but otherwise similar, the longer ship will expend a larger proportion of her power in turning, and thus her speed will drop more than that of the short ships. A ship with full deadwood aft expends more power in turning than one with the deadwood cut away, and therefore loses more speed. A ship with large turrets or other heavy weights at bow and stern requires more power to take up her swing at the beginning and more power to check it at the end, than one whose weights are more evenly distributed, and will thus have less power left for maintaining her speed.

For the above reasons, it is very important to group similar vessels together as far as possible.

Anchoring Simultaneously.

In standing in for an anchorage it is customary to slow to five or six knots while still some distance away and to stop when at a distance such that it is thought the ships will reach up to their berths with sufficient way left for anchoring. Supposing all the ships to be in position and moving at uniform speed when the fleet is stopped, it is assumed that they will continue in position. Unfortunately, this is not the case unless, as very rarely happens, they are all of the same displacement. Nor does it always happen that all are running at the same speed when the signal to stop is hauled down.

In running 500 yards, very marked changes of position may take place in a fleet where the displacement varies as much as it commonly does in most fleets of to-day or where some variation

of speed exists at the instant of stopping. It is worth considering whether it might not be well to keep the engines turning over at dead slow up to the instant of letting go the anchors. This would make it possible to keep the ships in position, and their headway need not be greater than it usually is under the present practice.

It is important that "half-speed" and "slow-speed" should be standardized as carefully as "standard speed" and that the leader of the column, when indicating either of these speeds, should maintain the proper number of revolutions as carefully as at other times. A little carelessness on the part of the leader when approaching the anchorage can make serious trouble for the ships astern. Similarly, of course, carelessness on the part of any ship in the column throws out all ships astern of her.

Getting Underway.

Notice having been given in advance, of the hour for getting underway, signal is made a few minutes before this hour to "heave short" and, at the proper time, to "get underway." If the ships chance to be heading in the proper direction, and if the flagship or other vessel which is to lead out of harbor is at the head of the column, the manœuver is very simple. If the ships are heading in some other direction, they should keep this heading after the anchors are up, until signal is made to turn *simultaneously*. If the flagship is at the inner end and proposes to lead out, it is advisable, unless conditions of wind and tide introduce some difficulty, for the ships to turn a little short of the course on which they will run out; that is to say, they should head one or two points toward the line along which the flagship will pass as she leads out. Each ship is then ready to drop into place as her turn is reached, remembering to gather way by taking up first *slow,* then *half,* then *standard,* speed, in time to take and hold position in the column.

It is much more common to see ships slow about getting into position than to see them closed up too far, the result being that in a fleet leaving port the leaders are often seen running at half speed while the rear vessels are closing up under reserve speed. This looks badly and there is no reason for it except undue slowness or timidity about taking position.

Handling Turbine Ships.

Most men-of-war of recent design have turbine engines, and must be handled somewhat differently from ships with reciprocating engines. Attention may be called to the following points of difference:

Turbine ships have small screws, which are run at high speed. In ships with reciprocating engines the conditions are reversed, these ships having large screws which run at comparatively low speed.

As turbines cannot be reversed, it is necessary to provide separate rotors for backing; and as it is not economical to divide the available space equally between the power for going ahead and that for backing, it results that the backing rotors are comparatively small.

In many cases turbine ships develop less than half the power in backing that they have for going ahead.

This is a point that can never be lost sight of for a moment when manœuvring in formation with ships having reciprocating engines. It is also of great importance in crowded waters or in a fog, in turning in a narrow space, in going alongside a dock, and in many other situations where it may be necessary to reduce the headway quickly.

Perhaps the most important loss which results from these conditions is in the power to turn in a limited space, where a ship with reciprocating engines and a good spread between her (large) screws can often be made to spin around on her heel by going ahead on one screw and backing on the other.

As it is necessary for reversing in a turbine ship to shift from one set of rotors to another, there is considerable time lost as compared with a corresponding shift in the case of reciprocating engines. It is found on the *Nevada* that, under average conditions, about a minute and a half is required.

As the head of steam is reduced in shifting from one set of rotors to another, there is a material drop in pressure where much manœuvring is called for, with the result that a ship which is obliged to shift several times in turning, as may be necessary in getting underway with other ships, is likely to find herself unable to pick up speed promptly after straightening out on her

course. This may be guarded against by having a good reserve of boiler power.

There are two distinct types of turbines in use in the U. S. Navy, viz.: The Parsons and the Curtiss.

The following notes refer to ships having the Parsons type as installed on the *Florida* and *Utah*.

There are four propellers driven by turbines on each shaft. The high-pressure ahead rotors are on the wing shafts, the intermediate and low-pressure on the centre shafts; the high-pressure backing rotors are on the wing shafts, the low-pressure backing on the centre shafts. The backing turbines are small and the combination has less than half the power of the ahead combination. Due to the less efficient clearance of the blades, the backing turbines use up steam very rapidly and therefore the backing efficiency of the engines is really less than the rated horse-power of the backing turbines would lead one to suppose. It should be noted also that after backing for a comparatively short time there is not a full head of steam left for going ahead until steam is worked up again.

Getting Underway. When getting underway the low efficiency of the backing turbines must be kept in mind at all times.

When casting in restricted waters the sternboard should be made towards the most restricted area on account of quicker effect of the propellers in going ahead.

The turning effects of the propellers in combination with the rudder are the same as with reciprocating engines, but slower. The effect of wind is the same, the ship usually falling off when going astern.

In a tide-way it is most important to bear in mind that the ship responds to her engines much more slowly than in the case of reciprocating engines with large propellers, particularly in backing. With way on ahead the ship answers her rudder practically as efficiently with her engines backing as when they are stopped or going ahead.

When getting underway in squadron where it is necessary to gain and keep position, it is well to remember that much manœuvring in turning materially reduces the head of steam, and it will be necessary to work it up again before full or even

[1] By Captain H. P. Jones, U. S. Navy.

standard speed can be maintained. As soon as the ship is straightened out on her course, permission should be given to the engine room to shift from manœuvring to cruising combination, in order to run the steam up as soon as possible. A very wise precaution is to have more power available than the prescribed speed requires until clear of the harbor, when a boiler may be taken off.

Coming to Anchor. When approaching an anchorage the low efficiency of the backing turbines must be kept in mind always. With steam for fourteen knots or under it is not advisable to let go the anchor with more than four knots way on. The engines should be stopped far enough from the anchorage for the ship to lose her headway to about four knots when the anchor is let go. This gives the fire-room force opportunity to bottle up steam for backing. It is well to remember that when steam is shut off from the rotors the propellers revolve freely, so there is no drag of the propellers to deaden headway. Headway may be deadened by quickly putting the rudder full over each way. If the harbor is an open one it is well to keep standard speed to the point where the engines should be stopped and let the ship slide up to her berth, rather than slowing gradually by two-thirds and one-third speed and then stopping near the anchorage point.

Cruising and Manœuvring in Formation. It must be borne in mind always that the ship responds slowly to changes of speed of the engines. The propellers are much smaller than in case of reciprocating ships with two screws. When cruising in formation with ships having reciprocating engines, their comparatively quick changes of speed must be taken into account and their action anticipated as much as possible. If astern of a reciprocating ship and the signal stop is made, the turbine ship will close up rapidly.

When turning, the rudder tends to check the speed materially and distance must be watched closely. If it becomes necessary to give more than the standard rudder in the turn, the engines should be speeded up immediately. If the rudder is put over full, the ship will lose distance rapidly in spite of full speed on the engines. Therefore it is better to turn outside than to attempt to turn short into column with a full rudder.

When manœuvring in company with reciprocating ships very great care and vigilance are required at all times, and the rudder should be depended on rather than engines in avoiding collision.

In a Fog. In a fog also the rudder must be relied on rather than the engines. The rudders are large and the steering qualities excellent. Stopping and backing the starboard engines when turning to starboard, and the port engines when turning to port, of course will quicken the turning very materially. Headway is lost slowly by backing the engines, but quickly by using full rudder.

Breakdown. The ship will carry her way a long time, as the propellers do not drag. Headway will be lost quickly by using a full rudder in turning.

Man Overboard. Rules are prescribed for this as a tactical manœuvre. But when acting singly or otherwise, when possible to do so, the quickest way to reach the man is to turn with a full rudder, stopping engines until the man is clear and then starting them again. Keep engines going until about half-way around, then stop. The ship will slide up close to the man and headway will be deadened enough to get boats away.

The following notes[1] refer especially to Curtiss turbines.

The remarks on Parsons turbines apply also to Curtiss turbines in all cases where a ship has four propellers. In oil-burning ships it is not necessary to make allowances for time to build up steam pressure for going ahead again after backing, even though the steam pressure has dropped due to the large volume of steam required for backing. This is due to the fact that as soon as the fire-room receives the signal "Full speed," enough burners are at once turned on to run the steam quickly up to the working pressure. The point is that the volume of oil flame under the boilers can very quickly be varied at will, which is of course not the case with vessels burning coal.

On the *Nevada,* which is equipped with only two propellers and Curtiss turbines, the time required to manipulate the necessary valves for stopping and backing is practically constant for all speeds. This time is from fifteen to twenty seconds. But the total interval of time elapsing from going ahead—say at twelve knots—to astern, depends entirely on the boiler power available. With full boiler power it would not take more than one minute to reverse the engines from full speed ahead. With

[1] By Captain W. S. Sims, U. S. Navy.

only one-third boiler power available (which is the minimum) it takes about two minutes to reverse and have the *engines* going one-third astern. With one-half to two-thirds boiler power available, about $1\frac{1}{2}$ minutes would be required to back at three-quarters the maximum astern speed.

Boiler power available.	Engines going ahead.	Engines going astern.	Elapsed time.
Maximum (12 boilers)	Full speed	Full speed	1 minute
$\frac{1}{2}$ to $\frac{2}{3}$ (6 to 8 boilers)............	15 knots	$\frac{3}{4}$	$1\frac{1}{2}$ minutes
$\frac{1}{3}$ (4 boilers, minimum for backing.	5–10 knots	$\frac{1}{3}$	2 minutes

The above times are approximate.

Generally speaking, the turbine ship having two propellers can be backed more quickly than the turbine ship having four propellers, since it takes less time for the steam to pass through the turbines, and since the propellers are somewhat larger. However, the total backing power is about equal in both Parsons and Curtiss installations.

Manœuvring. Vessels of the *Nevada* class have their deadwood cut away much more than other recent types. This results in improved tactical qualities, but this improvement tends to complicate, rather than simplify, the handling of the ship in formation with the older ships, such as the *Wyoming* and *New York* classes. The reason for this is as follows: Absence of deadwood has very little effect as long as the ship travels a straight course, but as soon as she begins to turn she turns very rapidly. This causes the ship to advance much further than the older ships when given the amount of rudder necessary to turn in the same tactical diameter. Conversely, if she is given enough helm to cause her immediately to follow in the wake of one of the older ships, she will describe a much smaller circle. Thus the vessel cannot be turned *in a prescribed tactical diameter* by using a standard helm without getting considerably out of position. That is, a varying amount of helm must be used in manœuvring with the older types of vessels.

Another peculiarity of this ship is the difficulty of steering with the engines. There being but two propellers, which are small (18 ft.) and set close to the center line (24 ft.), their steer-

ing effect is almost negligible. In fact, if the ship is swinging it is practically impossible to check her with the engines alone. At slow speeds, when there is considerable wind and sea, the ship has a strong tendency to come up into the wind, and it is often necessary to steam under one engine and with a considerable rudder in order to steer a set course. In a harbor, with little manœuvring room, and with but little way on it is difficult to turn against the wind. This condition is probably found only on the *Nevada,* since her sister ship, the *Oklahoma,* has reciprocating engines, and the later types, *Arizona* and *Pennsylvania,* have four screws.

In a Fog. Backing the inboard engine when turning with full rudder does not quicken the turn, but causes the ship to advance fifty yards less and transfer fifty yards less than when turning with full rudder and both engines going ahead. There appears to be a slight advantage in backing the inboard engine to avoid collision, though the headway is much reduced by the time the ship has turned 90°.

Man Overboard. There is no necessity for stopping the engines to prevent striking a man overboard. In the first place the tops of the screws are submerged 11 feet and the outboard edge does not project beyond the side of the ship; in the second place the screws continue to revolve for some time at practically the same speed after the throttles are closed, provided the ship has way on. The best thing to do is to manœuvre to lower a boat as soon as possible and as close as possible to the man. By using full rudder and turning 180° with both engines going ahead and then backing both engines the ship will be practically dead in the water at the point where the rudder was first put over.

In other respects the manœuvring qualities of the *Nevada* are similar to those described for the *Florida* and *Utah.*

Handling a Ship Propelled by Electric Drive.[1]

Before discussing the handling of the Jupiter, it will be necessary to give a brief description of the installation.

The ship is propelled by two induction motors using alternating current furnished by a turbine-driven generator. So far as the

[1] Notes by Lieutenant Commander Clarence S. Kempff. Commanding U. S. S. *Jupiter.*

generation of power goes, the *Jupiter* is a single-screw ship, as all power used by the motors comes from the one generator, which is driven by one turbine; but so far as manœuvring goes, she is a twin-screw ship, as the power is carried from the single generator to two motors and two shafts.

The generator has two poles and each motor thirty-six poles, so that eighteen revolutions of the generator are necessary for one revolution of the motor, which is secured to its respective propeller shaft. In other words, the propeller revolutions (neglecting slip in the motor, which is less than 2%) are always one-eighteenth of the number of revolutions of the revolving field of the generator.

The revolving field of the generator is on the same shaft as the rotor of the turbine so that one revolution of the turbine gives one revolution to the generator and 1/18 of a revolution of the motors and propellers.

Thus, in order to change the speed of the propellers, it is only necessary to vary the speed of the turbine which drives the generator; and all changes of speed in the vessel are made in this way. In other words, if the turbine and generator are making 1800 r.p.m. the motor will make 100 r.p.m., which gives thirteen knots. If the turbine is slowed to 900, or one-half the revolutions, the motors automatically, due to their construction and to the fact that they are induction motors, will make 50 revolutions, or speed for six and one-half knots.

Object and Effect of Resistances. There are two water-cooled resistances in the engine-room which can be thrown in or out of circuit with the rotor of either motor, and as these are cross-connected they must be thrown in or out on both motors at the same time.

These resistances have nothing whatever to do with the speed of the motors and propellers. Their function is to enable the motors to exert their go ahead or backing power on the propeller shaft *instantaneously*. The effect of these resistances is, in fact, to give the motors and propellers a practically instantaneous full-power reversal in either direction, either at fifteen knots or at any speed below that, the *speed* at which the motors operate when the resistances are "in" depending entirely upon the speed of the turbine and the generator field, as has been stated. It takes about four seconds to throw these resistances in or out of circuit.

As the motors are less economical running with the resistances "in," they are habitually kept "out" except in manœuvring where instantaneous reversal is desirable.

If running at a speed of fifteen knots, the highest speed the vessel can attain, the resistances can be thrown in and the motors reversed up to a speed of ten knots, in four seconds. Either motor may be stopped while the other is running in either direction.

Turning. A point that forces itself upon one's attention, and a vital one so far as manœuvring goes, has to do with the turning of a vessel, the motors (and propellers) of which must of necessity operate at the same number of revolutions whether both are going ahead or one is going ahead and the other astern. As a matter of fact the difficulties which might be expected to result from these conditions vanish under the test of actual manœuvring. The turning of the ship is accomplished by the application of power to the propellers in different directions, for certain periods of time. Consider the *Jupiter* turning to the right with full right rudder at 10 knots (77 r.p.m.) under the port motor, starboard motor being stopped. It is desired to turn faster. The starboard motor is signalled to back; and a second after the switch is thrown, that motor is making seventy-seven revolutions, —no more and no less,—astern. The ship picks up to the desired velocity. The signal is given to stop the starboard motor, and instantly the power is off. The inertia of the ship overcomes any jerky motion. In other words, with *two* motors that can supply absolutely definite amounts of power to the propellers as often as thirty times a minute, any uncertainty as to what is going on is removed, and greater facility of control attained.

It is one thing to have an order appear on the engine-room telegraphs and quite another to obtain an absolutely definite and practically instantaneous response. The handling of the *New Mexico*, when both pairs of motors are operated from one of her two turbo generators, will be similar to that of the *Jupiter;* but when the starboard and port pairs of motors take their power from separate turbo generators, of which there are two instead of one as in the *Jupiter,* the starboard and port pairs of propellers can operate at different speeds as reciprocating engines do, but with much greater promptness. One should be able to

"thread the eye of a needle" with the *New Mexico* if the two independent turbo-generators are in use.

Fleet Work. The manœuvring of the *Jupiter,* as required by the nature of the duties she must perform, is somewhat more complicated than falls to a reciprocating engine battleship, for the reason that the *Jupiter,* which displaces 22,000 tons, draws 31 feet when fully loaded, and as little as 20 feet when nearly discharged. She is 542 feet long, has only 65 feet beam, and has a considerable amount of top hamper, making the effect of wind a very important factor, especially when the ship is light.

Moreover the full horse-power is 7200 or about 1/3 H.P. per ton of displacement, which is about a third of that at the disposal of a reciprocating engine battleship. As the cargo is discharged, the ship is habitually trimmed down with water ballast; and for best handling trim a drag of from three to four feet is kept. If trimmed deeper by the stern, the wind effect on the bow resembles that upon a destroyer, and with the overhanging bow, an element of danger is introduced which calls for extreme caution in going alongside ships or coal piers.

Going Alongside a Battleship. In illustrating the procedure of going alongside, the *Texas,* which is a clear-sided vessel and longer than the *Jupiter,* will be considered, and special difficulties met with in connection with other vessels will be briefly mentioned later.

It is assumed that the *Texas* is anchored and that no obstacles interfere with an ideal approach. Standard speed for going alongside is ten knots; no reserve speed is provided for, as all handling is done well below the ten-knot limit.

(1) In approaching the battleship, pass under her stern and get her compass heading by a bearing of her masts when in range. This is necessary because the *Jupiter's* bridge is far forward and it is difficult to judge the exact angle of approach. Moreover, the curved form of the battleship is deceptive, and startling changes of viewpoint frequently occur as the two vessels come into close proximity.

(2) Place the collier about 1,500 yards from, and two points on the port quarter of, the battleship, the collier to be practically dead in the water at this time and on about the same heading as the battleship.

(3) Kick the collier ahead with the motor, using 1/3 speed or

⅔ if necessary to give her steerage way, ***and nothing more than steerage way,*** then stop motors. Approach at steerage way, using the engines as necessary. Avoid getting any more than steerage way on the collier, as a moderate speed is no longer moderate when the vessels draw together; and if backing becomes necessary, the control of the collier may be lost. Always keep the situation so in hand that you force the vessel to the battleship. Never allow yourself to get close aboard and abreast of her, trusting to backing *both* engines to make a safe landing alongside.

(4) Gradually change course so that your ship approaches the battleship at an angle of one point. This keeps the sterns of the ships separated and places the bow closer than any other part of the collier. Any effect of wind or current tends to set you slowly in; and besides this, if the battleship swings stern to starboard you can haul off a point and still be parallel, without getting the stern in and bringing the propellers of the two vessels together.

(5) As soon as the vessels are within heaving-line distance, pass your lines aboard; or if a boat is available, send over a heaving-line bent to a good hauling-line. By this hauling-line the bow-line and a spring are run simultaneously and carried as far forward as possible on the battleship.

(6) Work your ship parallel to the battleship, make fast the spring leading forward, tend the head-line, and if any current is running the collier will drop alongside; otherwise back ⅓ speed on port motor to assist. The advantage of using a spring leading forward, over one leading aft, is that the resultant of the wind and current forces, to which the battleship rides, all tend to make the collier do likewise. Moreover, less engine power is required to get alongside, the strain on the spring is taken on the battleship's anchor chain, and there is no tendency to tow her up towards her anchor, as with a spring leading aft, when the collier is forced ahead.

(7) Get stern lines over as convenient, but there is usually no urgency in this matter unless a wind blows from the battleship. Get out a spring leading aft from a point well forward, and place hatches as desired by the battleship. Never bother as to where the hatches will come till you are safely alongside and suitable lines are run to control the ship.

(8) Sometimes while close alongside, delay occurs in getting lines over. Pick out a mark on the battleship, say an awning stanchion, and hold the ship in position till lines are run.

The Broadside Landing. It sometimes happens that a wind of force four or even stronger is blowing you down, broadside, upon the battleship to which you must go. Under these conditions it is advisable to get abreast of the battleship and parallel to her, but outside of heaving-line distance. No strain should be taken on the bowline or bow spring when run, but the slack should be hove in as the collier drifts down. Keep the bow *out* about a quarter of a point and allow the after-fenders to take before the forward ones. If any current is running and the wind sets the collier toward the battleship, it is hard to work the bow out against them. If the bow blows down rapidly let go the port anchor, to check her. Conversely, it is well to be prepared to pull the bow out when the wind is blowing *from* the battleship when coming up from astern; for the bow of the collier is then under her lee while the stern is not.

Getting Clear. There is some difference of opinion among officers commanding colliers that do fleet work as to whether "backing away" or "going ahead" is the better method of getting clear of a battleship. I prefer to "Go ahead," if possible, for the following reasons:

(1) The pivoting point of the *Jupiter* is about ¼ of her length from the bow; it is therefore much easier to throw the stern clear than the bow, if in danger of contact.

(2) The bow is allowed to fall off not more than half a point before going ahead; and in this position any current tends to separate the vessels; and if the wind is ahead, that acts in the same direction. A short spring is used from a point forward of the propeller, where it cannot foul. This is kept fast while the bow is falling off, and run in when the collier starts ahead.

(3) When the collier starts ahead and the ships' sterns tend to draw together, backing the starboard motor throws the screw current, or "quick water," in between the ships, and first forces the stern away and then separates the vessels bodily. Of course the backing is only continued long enough to get the separating effect, and not long enough to materially check the collier's way. When starting away, set a course diverging not more than half

a point from the battleship's heading, and throw the stern out with some right rudder; then back the starboard motor to separate ships, if necessary.

(4) The collier can then be gradually eased across the battleship's bow, keeping clear of her chain, and allowing for current if any.

(5) A vessel is under better control going ahead than while backing, and good control is essential in close quarters.

Backing Away. In using this method it is necessary to watch for the following difficulties: In order to get clear, the stern must first be worked off about half a point. This forces the flaring bow of the collier close to the battleship.

The current, or wind, if the latter is from ahead, tends to force the bow towards the battleship.

Backing tends to back the stern into the wind, if it is ahead or on the port side, which increases the tendency of the bow to sweep the battleship.

By going ahead on the starboard propeller without stopping the collier's sternboard, a turning effect is gained; but as the pivoting point is well forward, this does not give as prompt or satisfactory results as are obtained in working the stern off in going ahead. Nevertheless no trouble need be anticipated in backing away, if care and skill are exercised.

Remember that the bow toward the battleship must pass her propeller before clearing, and, if too close aboard, may foul.

With a breeze blowing the collier toward the battleship, it is highly dangerous to attempt to back away.

Points to Keep in Mind.

(1) Never be in a hurry to get alongside—take it easy.

(2) If the collier handles badly, due to wind or other conditions, *back out while there is time.*

(3) When lines are run to a battleship, use as little engine power as possible. The vessels will come together quite rapidly enough. Do not force matters.

(4) Keep as large a reserve of power as possible.

(5) Coming up parallel to a battleship, then backing *both* engines, is dangerous. *Your starboard screw current tends to throw her across your bow, with her stern away from you.*

(6) Have both anchors hanging below the hawse-pipes and ready for letting go instantly, while working in the fleet.

(7) In going alongside a small vessel, ask her to heave short before you run lines. Let go your anchor and have her heave up at the same time. Then bring her alongside the collier.

(8) If by any chance the flaring bow overlaps the forecastle of a ship, and you fear that it may do some damage, go ahead full speed on the starboard propeller and back the port propeller full speed. Do not attempt to back away; you will sweep the battleship's side. Do not let the collier go astern. Hold your spring leading forward, bring the ships parallel, and then into position for coaling. If damage is done under these circumstances it will be less than will result from attempting to back out with wind or current setting you on.

(9) Be ready to get underway at short notice while alongside a ship.

(10) Trim your ship with water ballast as coal comes out, thus keeping her manageable at all times.

(11) Be on the lookout for a change of heading on the vessel you approach. She may swing unexpectedly.

Some Duties of the Officer of the Deck.

In concluding this chapter it may be helpful to call the attention of young officers to the magnitude of the responsibility which rests upon an officer in charge of the deck of a battleship at sea in company with a large number of other ships. Officers easily become so accustomed to the routine of cruising and manœuvring without accident, that they forget how close they may be at any instant, not only to accident, but to disaster.

It is not alone the mishaps of one's own ship which must be reckoned with, but those occurring to the ships ahead as well. It is true that if the next ahead stops her engines suddenly, she still holds her way for a time, and if the officer on her bridge is alert and self-possessed, he gives instant notice of the accident and hauls out of column. If the next astern is also alert and self-possessed, he sees the signal instantly and acts judiciously, and the danger is not great. The same is true of other accidents; such as a failure of the steering gear, a "man overboard," or an

unexpected manœuver to avoid a vessel or other danger suddenly discovered ahead.

But suppose the officer on the bridge of the ship ahead is slow to act, or loses his head and does the wrong thing, and in addition to this, neglects to signal that anything is wrong. If now the officer on the bridge of the next astern is as alert as he should be, and as ready to recognize and to meet the situation, all will still be well; but if he is giving his attention to other things, perhaps studying the chart, perhaps making an entry in the log, perhaps engaged in something far less justifiable than these, he may lose the brief interval in which he has time to act, or may be forced to act so quickly that his judgment will be at fault, and it may be his lot to become the responsible actor in an appalling tragedy.

It is perhaps essential that matters of internal routine should make some demand upon the attention of the officer of the deck at sea in squadron, but these demands should be reduced to a minimum, and should never for an instant cause him to forget the vastly more important demands connected with the safety of the ship. There should *at all times* be some responsible person on the bridge who is closely watching the movements of the ship ahead, and to this rule no exceptions should be made. If, therefore, the attention of the officer of the deck is for a brief time necessarily diverted to something else, he should caution the midshipman of the watch to keep an eye upon the ships ahead.

It is well to prepare oneself for prompt action by frequently picturing the emergencies which may arise and settling upon the proper methods of meeting them. This habit, coupled with the vigilance which will result from recognition of the fact that the emergency, if it is to come, will come without warning and when least expected, will give the only assurance that is possible, of readiness to meet it with credit.

It is one of the unfortunate features of an officer's preparation for his duties, that very few emergencies can be simulated—with their attendant features of danger and surprise—for purposes of training. The situation, for example, in which a vessel suddenly looms up, from a dense fog, close aboard of one of the vessels of a battleship fleet, requiring instant decision as to the manœuver which will be best for keeping clear at once of the

stranger and of the neighboring vessels of the fleet, is one in which no officer can hope for much practice, except in his own imagination. And so with many other situations.

Much is gained by making sure that all emergency arrangements are in working order, and that the men stationed to operate them are thoroughly acquainted with their duties; the breakdown flag rounded up to its place; the signal gun ready, with ammunition at hand; fireworks of any kind prescribed, in their appointed place; the life-boat ready for lowering, the crew mustered and inspected; men detailed to run aloft in case of man overboard, to keep him in sight and signal to the boat; a force detailed for shifting steering-gear in the event of a breakdown; men at the engine-room telegraphs for regulating the speed; men at the cones or other speed-signals for communicating with the ships astern; the position-buoy ready for going over promptly if there is a possibility of fog, etc.

While keeping lookouts up to their work, an officer should not trust to them but should remember that he is his own best lookout, and that if he sees danger first, he gains time which may be vital for avoiding it. This is especially important in a fog.

There is even greater gain in reading signals for oneself instead of trusting to signal-men who may be both stupid and careless. And it is a good rule to verify all tactical signals by reference to the Signal Book or to a memorandum in which the most important of the tactical signals are set down.

It is important also to note whether neighboring ships have apparently read the signal correctly and are starting out to perform the manœuver properly, as a mistake made by any one ship may be more dangerous to others than to herself.

Not only the officer and junior officer of the watch but the quartermaster and helmsman also should know to which side the ship is required to haul out in case of breakdown.

The officer of the deck should never enter the chart-room at night except in case of necessity. To do so, not only takes him away from a station which he ought never to leave, but makes his eyes useless for an appreciable time after he comes out. So with poring over the log or a chart—though the last may of course be essential.

It is important to keep the engineer officer of the watch in-

formed in advance as to changes of speed in so far as these can be foreseen, and to let him know how long a given condition will probably continue. If stopped or running slow this may save "blowing-off." It will also enable him to prepare for keeping position when "standard" speed is again called for.

It must be remembered that the Rules of the Road do not apply to vessels running at night without lights. A fleet running in this way must therefore keep clear of all vessels carrying lights.

CHAPTER XXI.

TOWING.

§ I. The TOW-LINE.

Generally speaking, the longer and heavier the tow-line used, the easier the towing will be. A decided dip or "catenary" gives the same advantage here as in the case of a vessel riding at anchor with a good scope of chain;—that is to say, the sagging bight acts as an elastic spring, preventing variations in the tension from being thrown upon the line in sudden jerks; and the sag of the bight depends not only on its length but on its weight.[1] Unfortunately, however, too great weight is a serious inconvenience in handling and running lines. This is the principal objection to chain-cable, which in many ways is an ideal tow-line. Another objection is that if the vessels are obliged to stop, the weight of the chain may prove sufficient to drag them into collision. In the excellent work on Seamanship by Captains Todd and Whall, the use of chain-cable (alone) is recommended for all cases of heavy towing; one of the authors testifying to its availability as the result of his own experience upon several occasions. This is high authority, but the present author has collected the views of more than forty prominent shipmasters, every one of whom says that under no circumstances would he attempt to tow by chain alone, unless compelled to do so.

Wire-rope is very convenient for handling, and makes an excellent tow-line for smooth water, but is much too light to give a satisfactory spring for all-around work under ordinary conditions. All of its advantages may be realized and its disadvantages eliminated, by the use of a *Towing Engine,* which sub-

[1] Observe that the dip does not in the least reduce the tension of steady towing. What it does is to furnish an elastic link between the ships, by which the forces already described as arising in a seaway are absorbed gradually instead of being thrown upon the line with the suddenness and disastrous effect of "impact."

stitutes the elasticity of steam pressure for that due to a long and heavy line. This will be referred to at greater length hereafter.

Both chain and wire have a serious disadvantage in that they are not buoyant, as are lines made from vegetable fiber.

Manila and **Coir**, while heavy enough to give a good dip if used in sufficient length, are not too heavy for convenient handling, and their buoyancy is a great advantage, particularly where lines are to be run by boats or hauled across over considerable distances. Manila, although much less buoyant than coir, is very much stronger and is probably upon the whole the most satisfactory line that can be used for moderate towing; but although heavier than wire of corresponding strength, it is still much too light for towing in a seaway. Its weight is increased in some cases by hanging a good sized kedge to the bight between the two ships;—a device which is evidently available with wire, as well as with manila. A more common plan is to use a combination of chain-cable with a manila or wire hawser, or both, the hawser being made fast to the towing ship and the chain-cable paid out by the tow.

When the conditions for getting the lines across from one ship to the other are fairly good, a combination of wire and chain is perhaps the best; but in bad weather, or when, for any reason, the ships cannot come close together for running the lines, the buoyancy of manila—its "floatability"—shows up as an enormous advantage, especially where the vessel which is to receive the line, get it on board, and secure it, is a small craft, such as a torpedo-boat or destroyer. The use of a manila hauling line helps out, but cannot do away with the difficulties connected with dragging a wire-line across a long stretch of water and securing it on the cramped forecastle of a small vessel which is perhaps plunging into a heavy sea. A good plan here is to combine manila and wire, the towing vessel first paying out the manila line, which is hauled across by the tow and secured, after which the towing ship shackles the wire-line to the manila and starts ahead very slowly, paying out the wire-line as she gathers way.

For towing a destroyer in rough weather—and it must not be forgotten that rough weather may be encountered in almost any

towing expedition—the full length of an 8-inch or 10-inch manila line with the added length of a 5-inch or 6-inch wire, will be none too much.

Where the tow is able to haul across and handle a wire-line, and especially where she proposes to use with it a good length of her own bower-cable, a 6-inch or 7-inch wire-line is recommended. The length that is needed will vary with circumstances, but it is far better to have too much than too little; and the use of a margin of safety which seems unreasonably large may result in a very comfortable security from the vexatious accidents and delays which are so common in towing.

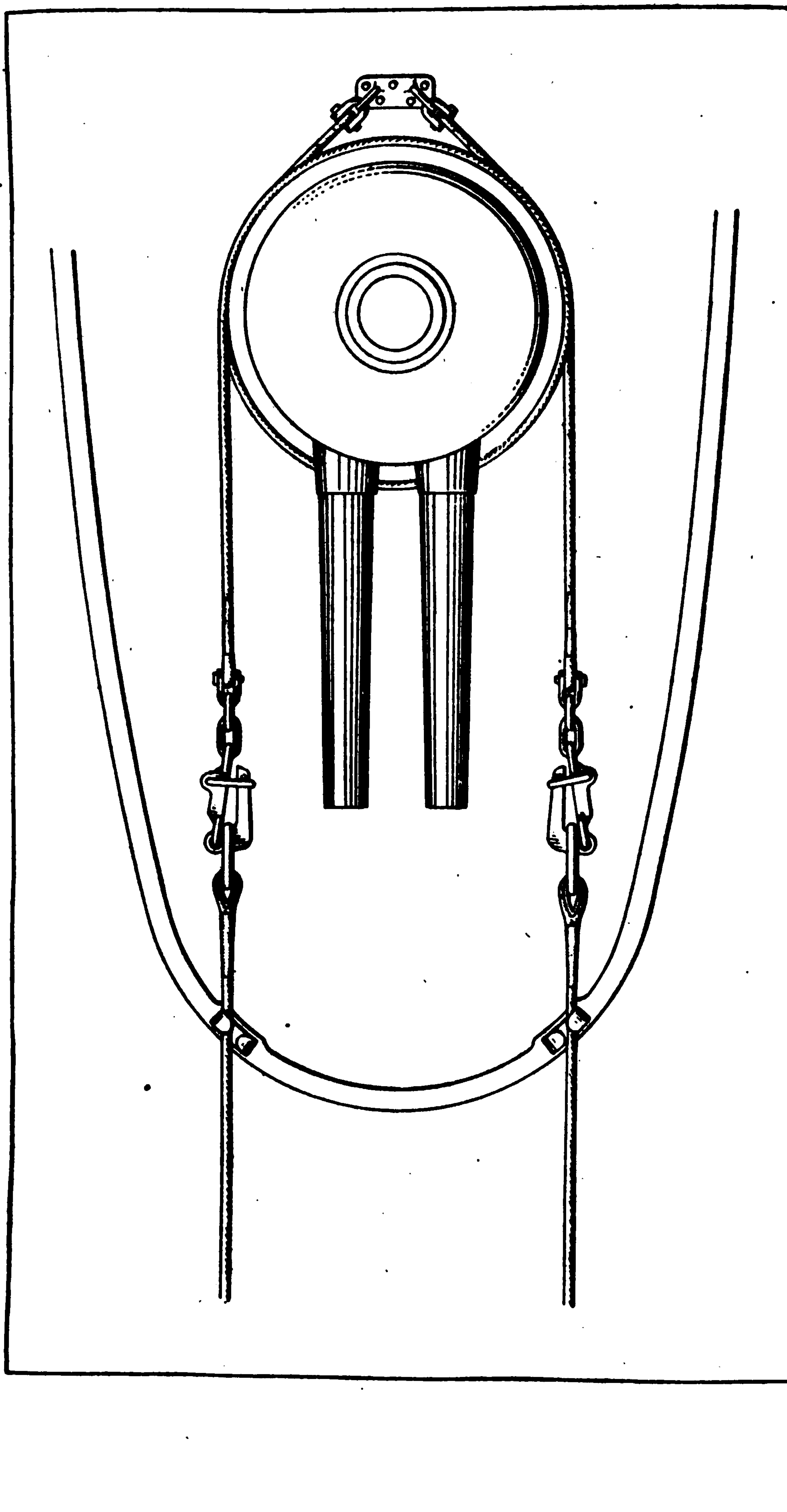
Where a battleship is to be towed, the full length of a special 7-inch wire-line (200 fathoms) is recommended, in addition to 75 or 90 fathoms of bower-cable. With such a line there should be no troublesome break-downs *unless the speed is forced unduly.* (See remarks below on "*Speed and Resistance.*")

Securing on the Towing Ship. In securing the line, consideration must be given to the possible necessity for letting go in a hurry. It is clear that there are many emergencies which may arise in which the line must be gotten rid of in the shortest possible time; such as a sudden threat of collision. This is a point which is not always given the consideration to which its importance entitles it.

For convenience in letting go, it is desirable to have a break in the line near the stern; that is to say, to have, at or near this point, a shackle connecting two parts of the line, together with some arrangement, like a pelican-hook, for slipping quickly.

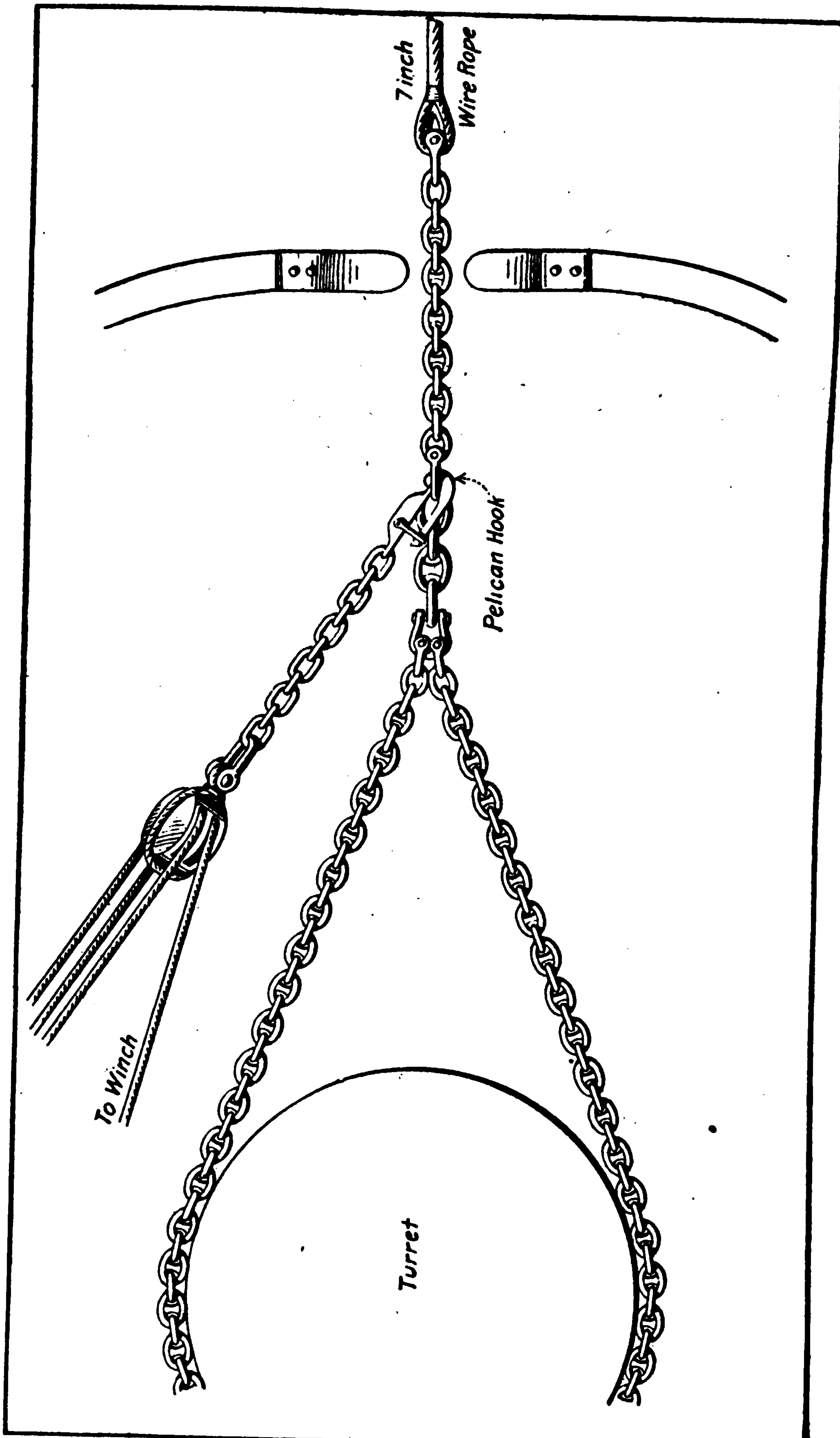
The objection to letting go at any point well inboard of the ship is that a dangerous "whip" is certain to result as the end of the line goes out.

To have the end only just inside the stern-chock on the towing ship means that practically the whole length of the tow-line must be paid out, and that any variation in length must be taken care of by the tow. As it happens, this is usually the simplest way to arrange matters, provided the bower cable of the tow is in use as a part of the line, as it almost always is. It is very easy to heave in or veer away on this, as may be necessary for shortening or lengthening the line.



TOWING A BATTLESHIP.
(BRITISH NAVY)

Plate No. 139.



TOWING A BATTLESHIP

A point of some importance in towing in a seaway is to keep the ships "in step" as nearly as may be; that is, to use such a length of line that they shall meet the waves and ride over them together. If the length of the line is such that one vessel is in the trough of the sea as the other is on the crest, the line will for a moment slacken, then tauten out with a sudden jerk; whereas if they meet the waves at the same time the tension on the line will remain comparatively steady. The wave-lengths of a sea are usually approximately uniform at any given time, and it should not be difficult to arrange the line as above described by heaving in or veering away the cable on the tow. In towing for a long time and covering a great distance, extreme variations may of course be found in wave-lengths, and the inconvenience of changing the length of the line from time to time may more than offset the advantage to be gained; but it is worth while to recognize this point and to be ready to take advantage of it when circumstances permit.

If the towing ship has a chock at the stern and amidships or nearly so, the line should be brought in through this. It is a good plan to use a short length of chain for the lead through the chock, shackling outside to an eye in the end of the wire-line, and inside to a pendant or span from the turret, the bitts, or elsewhere, according to the arrangement decided upon for securing. The chain through the chock not only takes the chafe—under which the wire would cut through—but by its flexibility does away with the dangerous "nip" which would be thrown into the wire if the tow chanced to take a rank sheer off onto the quarter.

If it is thought that the chain may suffer from chafe, a perfectly efficient sleeve may be made by wrapping it with a sheet of copper from 1/8 to 1/4-inch thick.

If chain is not to be used for taking the chafe in the chock, the tow-line must be very carefully protected by chafing-gear, which it is well to put on in the shape of a long and bulky "pudding." The stiffness of such a pudding reduces the sharpness of the nip which without it would be thrown upon the wire from time to time by the sheering of the ships.

The arrangements for securing the line inboard *on the towing ship* will vary widely with conditions.

In men-of-war, a pendant of wire or chain is sometimes taken around the after turret, as in Plates **138** and **139**. The first of these plates shows the method used in the British Navy where one battleship tows another. Two lines are used here—a plan which has some advantages and a good many disadvantages. The

second plate shows what is considered to be upon the whole the best arrangement for heavy towing. A wire pendant may of course be used around the turret, instead of the chain here shown.

In a ship having no turret, the pendant may be taken around a deck-house, with a few turns around the bitts on each side, as in Plate 140.

Where the strain is not too heavy to be taken by the bitts, the arrangement will be that shown in Plate 141, the line being taken around as many sets of bitts as are available. To divide the strain here, it is advisable to take only one or two turns around the first bitts, thus leaving the line free to "render" slightly and so transfer a portion of the strain.

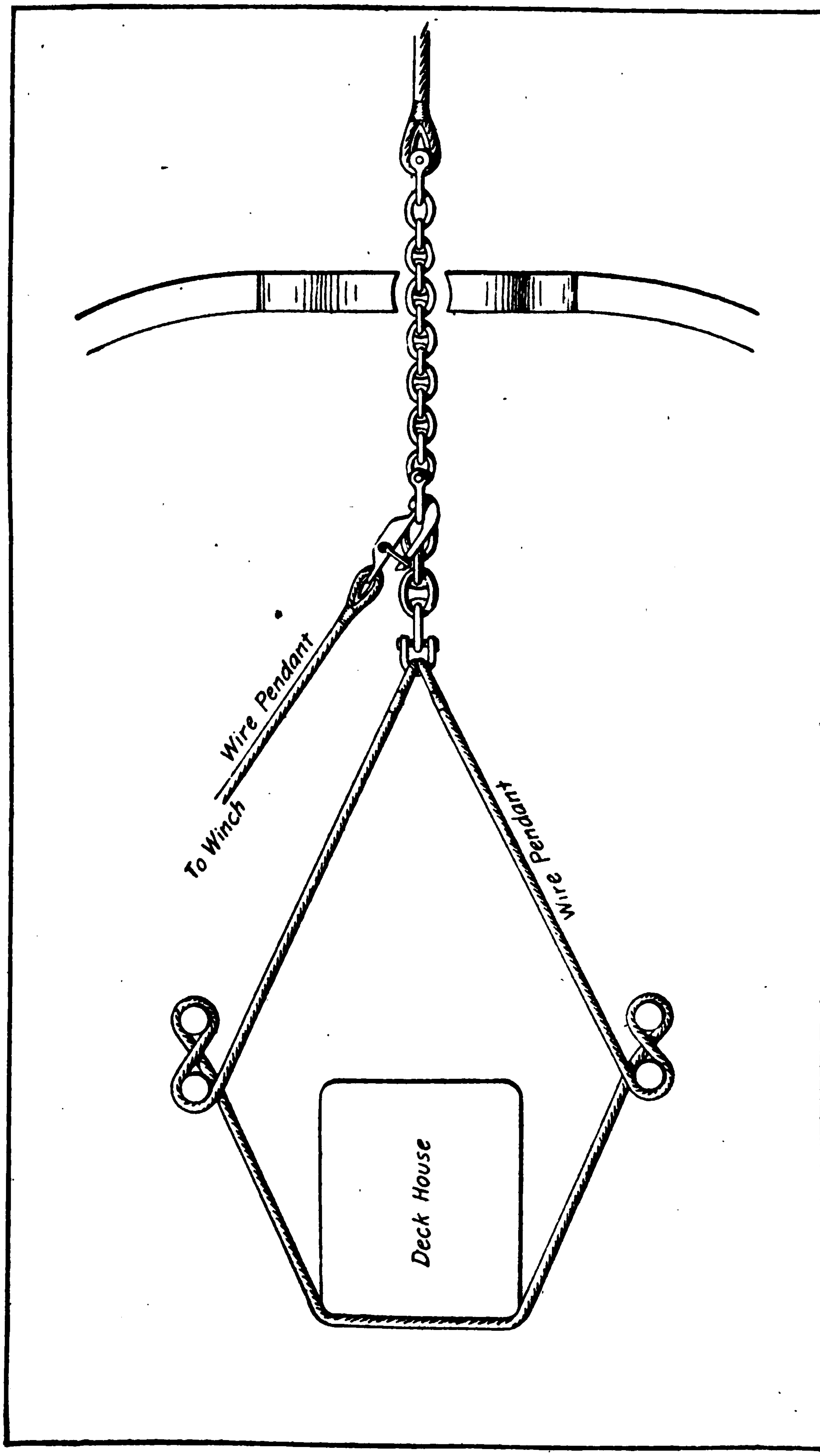
In all of the arrangements shown in the plates, pelican-hooks are used for letting go. In the case illustrated in Plate 138, the hook has the weight of the tow at all times.

In the other cases, the strain is taken momentarily on the hook, relieving the shackle and admitting of knocking out the shackle-pin, after which the pelican-hook is slipped. This arrangement entails a little delay, which, however, need not exceed a few seconds, and the whole arrangement is more secure than that of Plate 138.

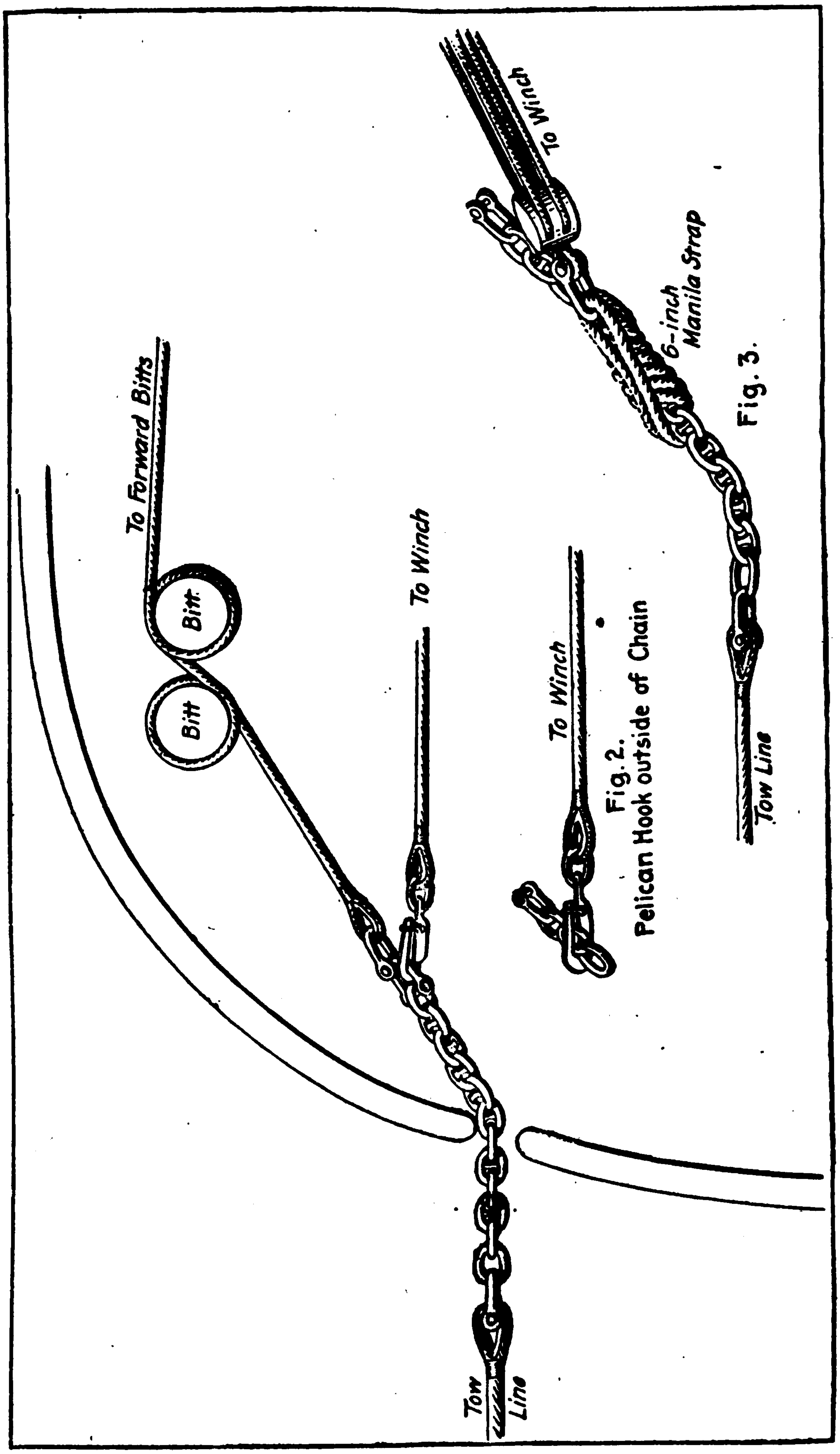
If it is not convenient to use an extra shackle for the pelican-hook, the hook may be used directly on the chain, as in Fig. 2, Plate 141.

If no pelican-hook is at hand, a strap may be used on the chain or wire, outside of the shackle, and a heavy purchase hooked to this and taken to the winch. For letting go, the strain is taken by the winch long enough to disconnect at the shackle, after which the strap is *cut*. (Fig. 3, Plate 141.)

There are some conditions under which it is convenient to use a *span* on the towing ship, the two parts being brought in through the quarter-chocks. Generally speaking, this makes it rather easier for the towing ship to steer and the advantage gained in this respect may become important in cases where a small ship is dealing with a heavy tow. Where the line leads from a chock directly over the rudder, it binds the stern so that it can only swing in obedience to the helm, by dragging the tow with it. A large ship can take care of this situation by the power of her steering gear, assisted, if necessary, by the screws; but a small ship with a heavy tow and with the line leading through the



Towing By Deck House And Bitts.



TOWING BY BITTS.

stern chock, if she steers at all will be very sluggish. Tugs which are specially fitted for towing have their bitts well forward of the rudder, allowing a chance for the stern to swing; the fittings abaft the bitts being such as to let the line sweep freely across from one quarter to the other.

Where a span is used it may be of chain, wire or manila, chain being probably the best. In this, as in other cases, arrangements must be made for letting go quickly if necessary.

Where chain is used for the span, two lengths of bower-cable are gotten aft, one on each side, and passed through the quarter-chocks. The outer ends are then brought in over the rail and connected together by an anchor shackle, to which the end of the towing hawser or chain is also made fast (Plate **142**). A bull-rope is made fast to the shackle, for lowering the span over the stern after the lines have been secured and for heaving the span up to the rail if the line parts or if it is desired to let go.

The details of securing the lines inboard must of course depend upon circumstances, but it is important to distribute the strain over as many sets of bitts as possible.

A convenient plan is to bring the tow-line in through the quarter-pipe on one side and bend a hawser to it from the other quarter-pipe at such a point outside that the two parts shall form a span of convenient length. The lines may be made fast around the bitts and to the mast or a deck house in practically the same way as in the methods already described. This plan has the advantage that by letting go the second line we get rid of the span at once and have to deal only with the tow-line itself.

On board the tow, the hawser is usually bent to the bower-cable (Plates **142, 143**), although there may of course be many conditions under which some other arrangement will be necessary. If the cable cannot be used, it is desirable to use at least a short length of chain to take the chafe in the chock in the same manner as already described for securing on the towing ship. If even this is impracticable, abundant chafing-gear must be used, and this should be examined several times a day and renewed as often as may be necessary.

Where the bower cable is used, the line is bent or shackled to it and the cable veered away to the desired length, after which the windlass brakes are set up and springs, to take the real strain of towing, are put on as in Plate **143**. It is well to have a shackle

between the windlass and the point to which the springs are bent and to keep tools at hand for unshackling if it becomes necessary to let go in a hurry. Generally speaking, however, the tow should not let go in this way except in case of extreme emergency, as the line, weighted with a considerable length of heavy chain, would sink immediately, hanging as a dead-weight from the stern of the towing vessel, where it would be extremely difficult to handle and would be in danger of fouling the screws. This applies only to cases where the tow is a vessel of some size, and where she is towing by her bower cables. It is evident that where a large ship is towing a small one, the natural way of casting off is for the tow to let go, leaving the line to be handled by the large ship. There is here, however, no question of a heavy chain-cable hanging from the end of the line.

In the more general case where the bower-cable of the tow is in use, the natural way to let go is for the tow to heave in her cable and then cast off the line.

There may, of course, be cases where the towing vessel is the proper one to let go, leaving the tow to handle the whole of the line. And cases may arise in which both vessels must let go, sacrificing the line to avoid some serious danger.

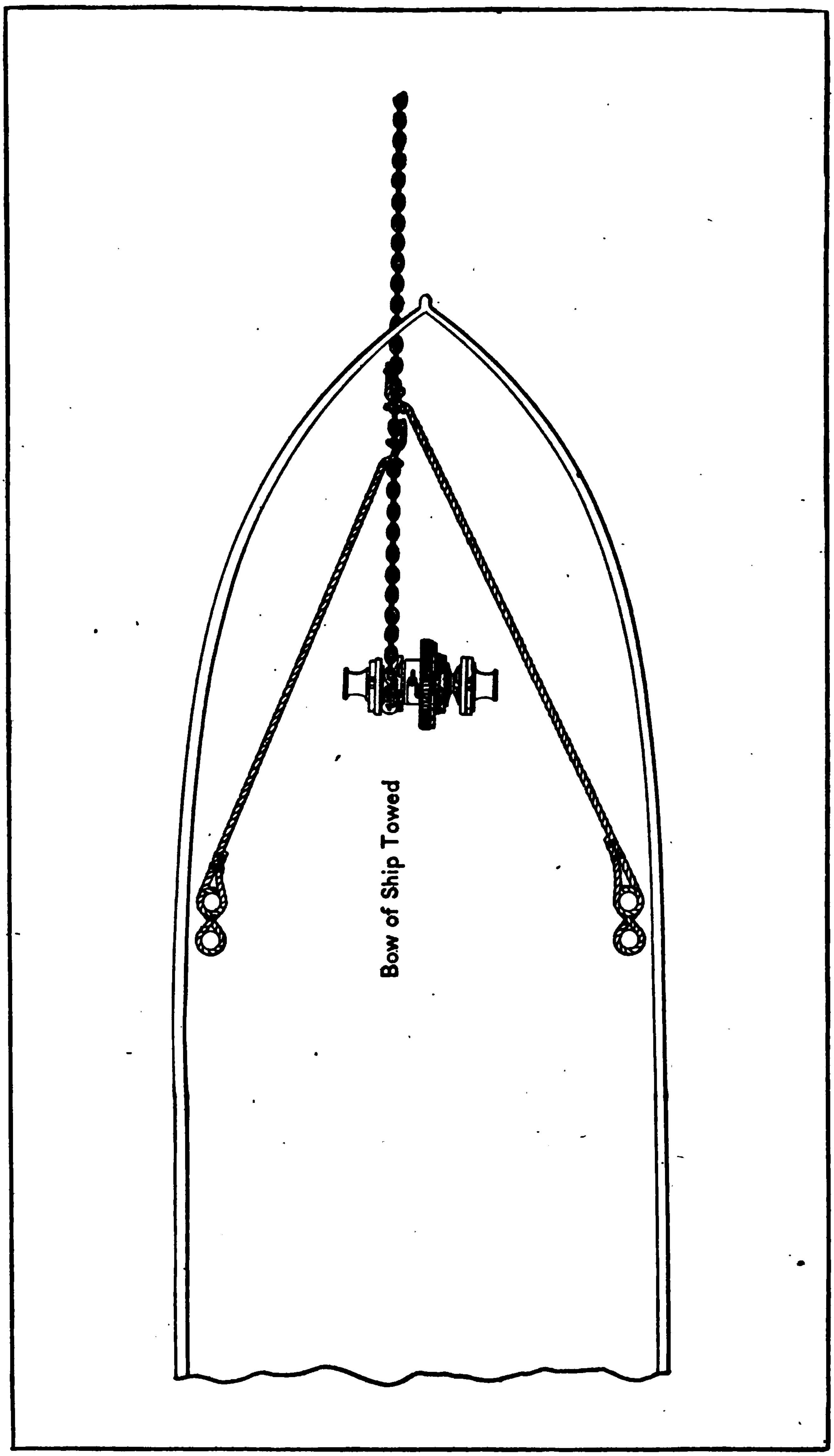
NOTE.—It is well to remember that in an emergency the towing vessel may safely back her engines without letting go the line and without danger of fouling the screws; but this must not be continued long enough to check her headway altogether—much less to let her gather stern-board—as to do this would involve danger not only of getting the line into the screws, but of being rammed by the tow. *On the tow, the helmsman should always be alert and ready to sheer out in case of ranging up onto the towing vessel.*

A plan which has many advantages for securing the line on the tow, is to bend it to the crown of the anchor and let the anchor go, veering chain to the proper length. Not only does this save the time required for unshackling, but it leaves the anchor on the bight of the line, where it should be very helpful in the matter of "dip." If the strap shown in Plate 90 is at hand, it will be very convenient here.

Naturally, this plan would not work in shallow water, as the anchor would take on the bottom.

Towing a Vessel with a Manila Hawser Bent to Bower Cable.
(Anchor Shackle)

SECURING TOW-LINES.



SECURING LINES IN TOWING.

Attention has been called to the difficulties connected with handling lines on the cramped forecastle of a small craft like a destroyer. Another point to be noted here is that the bower-cables of these small craft are not well suited for use as a part of the tow-line, and even if they were otherwise adapted to the work the difficulty in letting them go for casting off in a hurry—especially in bad weather—would be an insuperable objection to their use. A plan for securing the lines on vessels of this type is shown in Plate 144. Here a wire pendant is passed around the conning-tower and to this is shackled a pelican-hook which engages a length of chain sufficient to pass through the "bull-nose" and leave a little drift outside.

The pelican-hook should be large and heavy, as it takes the full weight of the tow. It must be fitted with a lanyard leading to the bridge, by which it can be tripped without sending anyone onto the forecastle. To the end of the chain is shackled a pendant of wire-rope long enough to lead aft, outside of all, to the bridge or some other point at which it is convenient to handle lines even in bad weather.

The line from the towing ship, which is preferably of manila for reasons already explained, is hauled over to this point of the tow and shackled to the wire pendant, after which the bight is let go, giving a clear lead.

For casting off, it is only necessary to trip the pelican-hook.

Where time permits, it is very desirable to prepare for towing operations by splicing eyes, with heavy thimbles, into all lines which are to be used, and providing shackles for connecting up at all points, thus doing away with the necessity for using bends and hitches, which weaken manila very seriously and are fatal to the efficiency of wire. At least two short lengths of good chain should be provided for the leads through the chocks on both the towing ship and the tow, and it will not be amiss to have two or three other lengths of, say, a fathom each, for use at any point where they may be wanted. Two or three wire pendants with a thimble eye at each end will be needed also. The plates illustrating this chapter will make it clear where these various parts are needed.

The pelican-hooks should be so heavy as to give a very large margin of safety. This is especially important where the stress

of towing comes continuously on the hook. The link which engages the hook should be long enough to let the tongue of the hook slip freely through on letting go and if the chain which is to be used is not fitted with an end link of this character, a shackle should be used. This is often the most convenient plan, and it illustrates the importance of keeping on hand a number of spare shackles for general utility. Such shackles are preferably larger and more open than those commonly used with chain-cables.

It should be remembered that the stud may be knocked out of a link to admit of using it with a shackle, without weakening the link.

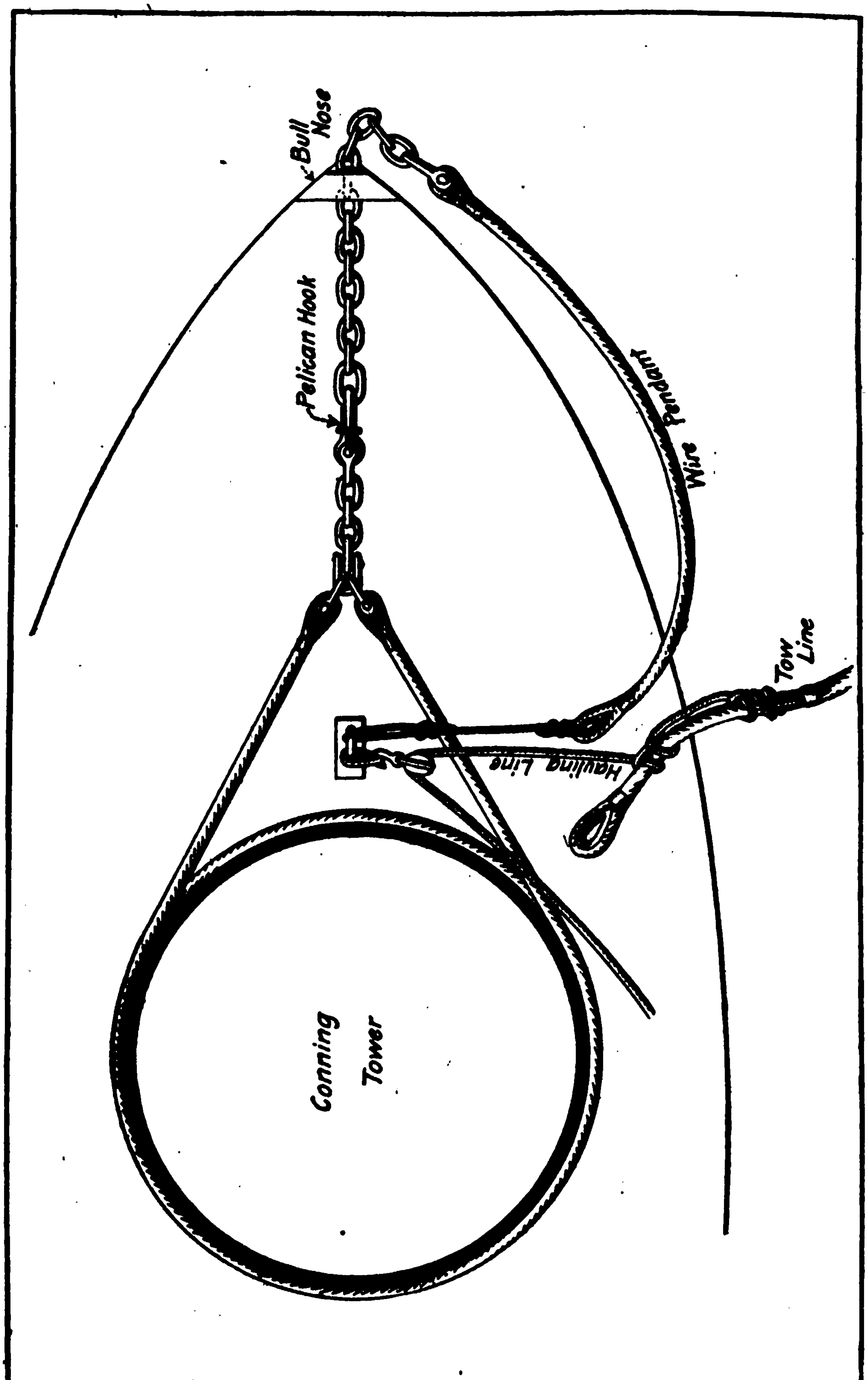
For getting the line across, in good weather, any one of a number of methods will answer. It may be run with a boat, a good length of the line being coiled in the stern-sheets and the remainder paid out as the boat pulls away. The towing ship is usually the one to send the line and should place herself, for this purpose, to windward of the tow. This not only gives the boat an easy pull to leeward, but makes a lee for her to work in. If the ships can come close enough together to admit of heaving the line across, this is of course a convenient method. For this, it is well for the tow to come up under the lee quarter of the other ship, being careful not to range up alongside far enough to let her stern overlap the stern of the other vessel. So long as her *stern* is well clear, she is free to sheer out and haul off if she finds herself getting too close or if the other vessel seems to be drifting down upon her.

If the vessels are practically abeam of each other and too close for comfort, neither one can haul off because to do so means that she must throw her stern in toward the other vessel.

For getting the line across under these conditions, it is well to begin with a light fish-line, weighted at the end with a piece of lead or iron of convenient size to fit comfortably in the hand and to admit of a long throw. The line is flaked down on deck, clear for running, and the weight is thrown like a baseball. It is possible to cover in this way several times the space that can be covered by the usual "heaving" line. The heavier lines are of course hauled across later.

Other methods, especially applicable to bad-weather conditions, are described below (§ III).

Plate No. 144.



SECURING LINES ON SMALL CRAFT.

§ II. SPEED AND RESISTANCE.

In smooth water, the tension on the tow-line will be constant, after the inertia is overcome, so long as the speed does not vary. The following table gives the approximate values of this tension for ships of various sizes when towed at speeds from 2 to 8 knots.

APPROXIMATE TOW-ROPE RESISTANCES FOR SMOOTH WATER.

Displacement of Vessels towed.	Speed.			
Tons.	2 knots.	4 knots.	6 knots.	8 knots.
1000	310 lbs.	1250 lbs.	2800 lbs.	5000 lbs.
2000	540 "	2050 "	4800 "	8600 "
3000	675 "	2700 "	6050 "	10800 "
4000	830 "	3300 "	7500 "	13500 "
5000	960 "	3800 "	8600 "	15000 "
6000	1075 "	4250 "	9500 "	17000 "

Note that if the vessel towed is long and fine, the resistances will be less than those above, while if she is short and bluff, they will be greater.

It must be understood that the resistances of the above table suppose the vessels *to be actually moving with the speeds given.* When the tow is at rest, the problem of overcoming her inertia and getting her up to the uniform speed desired, is very different from that of towing her after she acquires this speed; and as something of a jerk is inevitable, it is essential to use a line considerably longer and stronger than would be necessary for steady towing.

The tauter the line can be made before the towing vessel starts her engines ahead, the better it will be. She will of course start as slowly as possible, and, having overcome the inertia of the tow, work up, a fraction of a turn at a time to the speed required. In gathering way at the very beginning it is well to give a few turns ahead, then stop the engine, then give a few more turns and stop, and so on.

To the resistances of the above table must be added a large percentage for the dragging screws of a steamer. This may be as much as 75 per cent of the resistance of the hull alone. Moreover, the resistance increases very rapidly—and, what is of more importance, becomes very irregular—where we have to deal with even a very moderate sea, especially if the sea is ahead. The wind must also be taken into account, its effect varying with the cross-sectional area exposed by the tow.

As a rough rule we may say that the resistances given in the table should be multiplied by a factor of 3 or 4 for what may be called "average" conditions of wind and weather at sea, and that this factor should be increased to 5 or 6 where conditions are distinctly unfavorable.

Where a very large ship, like a battleship, is to be towed, it is safe to say that 8 knots is about the maximum speed which should be undertaken with any lines which are likely to be available. It will be seen from the table of resistances for smooth-water towing that the resistance added by an increase of a knot rises very rapidly as the speed increases.

This point becomes very marked as we go above 8 knots, and it seems probable that any promise of gain in time based upon a gain of one or two knots in speed of towing will be much more than off-set by the delays due to failure of the lines.

The remarks which have already been made as to the advantage of a very high factor of safety in the towing arrangements are of course emphasized in the case where the ship to be towed is a large and heavy one, and practical experience in long-distance towing cannot fail to demonstrate the wisdom of making this factor much larger than is likely to seem necessary in the beginning.

§ III. TAKING A DISABLED VESSEL IN TOW AT SEA.

In good weather, this manœuver presents no especial difficulty and calls for no extended discussion. The lines are run and secured as already described. The towing vessel starts ahead slowly on the course upon which the disabled vessel happens to be heading, using every precaution to prevent a jerk on the line, and waiting, before changing the course, until both ships have gathered way and are moving steadily with a good tension on the line.

In very bad weather, on the other hand, towing should not be attempted unless exceptional circumstances make it necessary; as the running of lines in a heavy sea is attended by considerable difficulty, especially if the vessel to be towed is unable to assist by placing herself in a favorable position. Moreover, in really heavy weather, it would be necessary to proceed so slowly that little or no time would be lost by waiting for the weather to moderate.

It will be considered in the discussion which follows, that the weather is rough enough to call for the use of all reasonable precautions, but not rough enough to make towing impracticable. It may be assumed that the disabled vessel will be lying with wind and sea a little abaft the beam;—this being the position which a steamer usually takes up when lying in a seaway with engines stopped. The other vessel places herself on a parallel heading, either to windward or to leeward. In considering which of these positions is to be preferred, we must remember that a considerable time will be required to run the lines; and that, during this time, both vessels will be drifting to leeward at a rate which may make their drift a very important factor in the problem of manœuvring. A vessel which is light will drift faster than one which is loaded, the drift of a vessel in ballast-trim amounting often to several knots an hour. If the lighter vessel is to leeward, she will drift away from the other, making it very difficult to run the lines. It may be said, therefore, that as a general rule, if there is any important difference in the rate of drift of the two vessels, the lighter one should be to windward when the work of running the lines is begun.

If there is any doubt as to which vessel is drifting the faster, this can be determined in a few moments by placing the one which is able to manœuver, in line with the other and on the same heading.

The towing vessel, then, places herself to windward if she is drifting faster than the other vessel, and to leeward if she is drifting more slowly, and on the same heading as the disabled vessel; taking care of course, not to run any risk of drifting into collision, and remembering, as the ships draw together, the caution already given not to get so close that the helm cannot be put over for hauling off without danger of throwing the stern into collision with the tow.

The vessel which is to leeward uses oil freely, creating a "slick" in which the boats can work.[1]

Some seamen recommend placing the towing vessel to windward and heading up to the sea or nearly so. But to hold her up in this position it would be necessary to keep the engines

[1] The oil from a vessel drifting in a seaway will not spread to leeward as fast as the vessel will drift. It is therefore impossible to make an oil-slick on the lee side, except, perhaps, very close aboard.

turning, which would result in drawing away from the other vessel and add greatly to the difficulty of the situation.

Where the difference in the rate of drifting is considerable, the time available for running the lines after the work is once begun will be short at best and every precaution should be taken to prevent delay; a clear understanding being established between the ships and all preparations made, before the towing ship takes her position as above. In communicating between two ships, megaphones are of the greatest value. Under any except the most unfavorable conditions, they should make it possible to perfect a thorough understanding of what is to be done and how. They also to a great extent take the place of signals between the two ships after the towing begins, although a code should by all means be adopted and will be useful under many conditions. It is an excellent plan, when feasible, to send an officer on board the tow to remain there permanently; acquainting him first with the plan to be carried out and providing him with a list of whistle- and sight-signals for handling the lines and the ships. If no boats are to be used, a paper should be floated across to the tow, giving full instructions and a list of the signals. This may be sealed up in a bottle and attached to the rope or the float. Whistle signals are preferable to flags, because they can be used at night or in a fog.

The following is suggested:

Code of Sound Signals for Towing.

A short blast must not exceed 2 seconds in length.

A long blast must not be less than 6 seconds in length.

I am putting my helm to port[1]	1 short blast.
I am putting my helm to starboard[2]	2 short blasts.
Go ahead	2 long.
Stop	1 long, 2 short.
All fast	2 long, 1 short.
Haul away	2 short, 1 long.
Let go	2 long; 5 short.
Pay out more line	1 short, 2 long.
Avast hauling	3 short.
I am letting go (emergency)	5 short, 5 short, 5 short

1. right rudder. 2. left rudder.

The first line to be run will be a light one, by means of which the heavier ones can be hauled across. A 3-inch manila is a convenient size to begin with. If new, so much the better, as it will float freely. If a boat is to be used it should be lowered with the crew and the greater part of the line in it, and gotten clear as quickly as possible, the line being paid out as the boat pulls away for the other ship.

If it is not thought best to use a boat, the line may be floated alongside the disabled ship without much difficulty. The best way to do this will depend upon circumstances, but a common way is to float a good length of the line by life-belts, casks, or any other convenient means, and to steam slowly around the disabled vessel, dragging this astern and causing it to foul her. If proposing to take up a position on her weather bow it is a good plan to steam along to leeward, fairly close aboard, cross the stern, and come around parallel to her heading. This will cause the line to foul her stern, which entails a little trouble in shifting it forward, but it leaves the towing ship in position without further manœuvring. Similarly, if proposing to take a position on the lee bow, pass along to windward, cross the stern and come around to leeward. The line should be picked up without difficulty.

Many vessels are provided with rocket guns throwing a line-carrying projectile similar to that used in the life-saving service. This is very useful and may save a great deal of trouble and delay. Such a gun is shown in Plate **145**.

An ordinary ship's rocket affords another and an excellent method of establishing communication. Such a rocket will carry a small fishing-line over 200 feet athwart the wind. If proposing to use this method, it will be better to go to windward and as close as is prudent. The fishing-line is faked down on deck, clear for running, with one end fast on board and the other bent to the rocket stick a few inches from the end. The rocket is given a good elevation (about 45°), and fired. If connection is successfully made, a somewhat heavier line is bent on and hauled across and so on until a sufficiently heavy one has been run to haul over the tow-line. If the wind is blowing across, it will carry the bight of the line and hence the tail of the rocket, to leeward, causing the rocket to work up to windward. Allowance must be made for this.

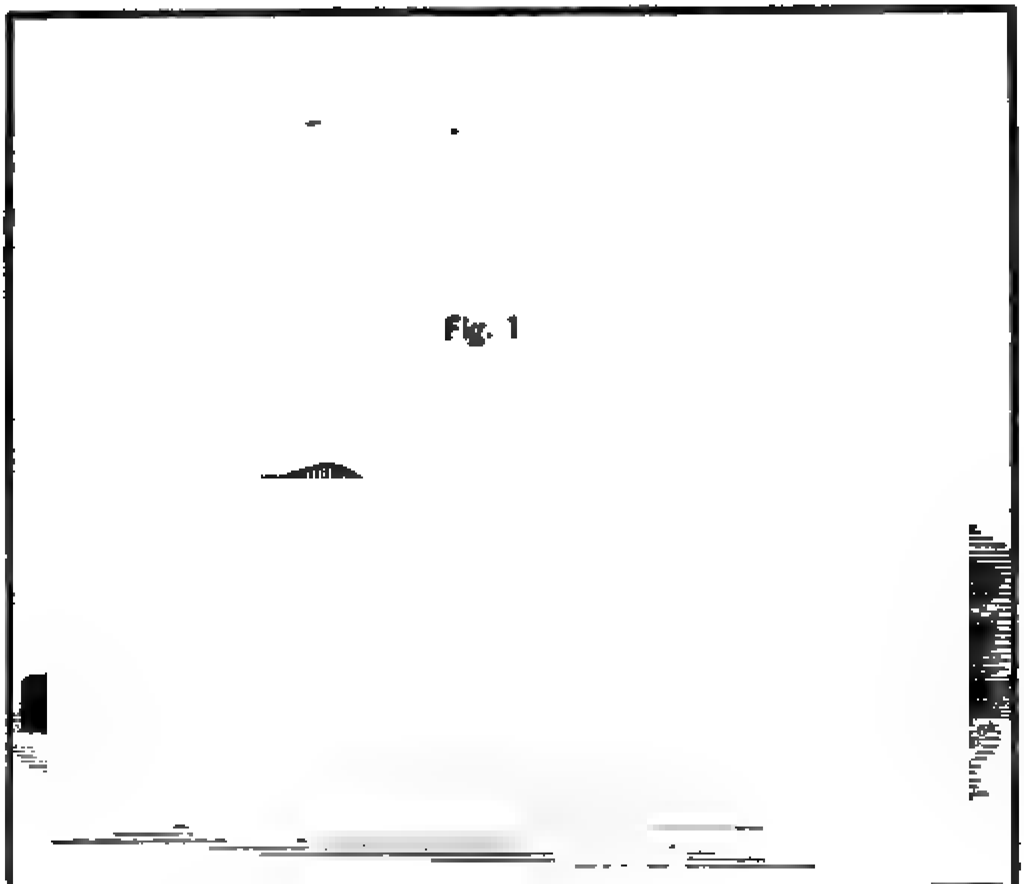


Fig. 1

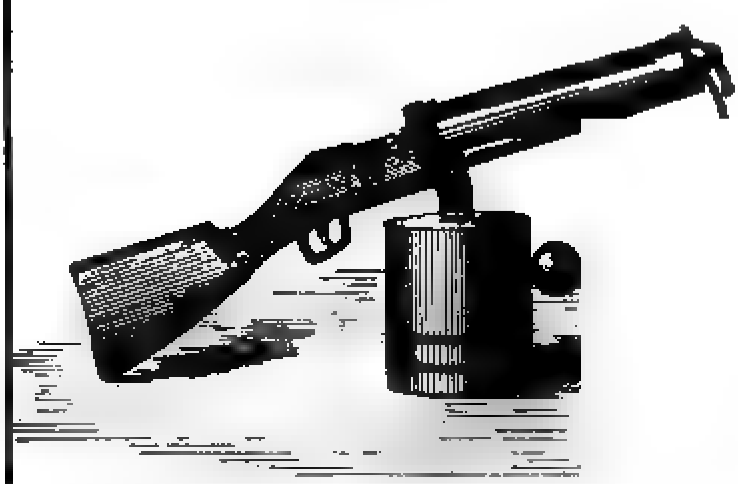


Fig. 2

LINE-THROWING GUNS.
(G. Cordes, Bremerhaven.)

There may be special circumstances which will make it desirable for the disabled vessel to run the lines, but under ordinary circumstances it is more convenient for the towing vessel to run them. Having gotten the first light line across, by whatever method, the heavier lines are run and made fast to the bower-cable of the vessel to be towed. A good length of cable is paid out;—60 or 75 fathoms is none too much for heavy work;—and the line made secure on both ships as has been described in § I, chafing-gear being used liberally wherever it can be needed. In the meantime, full instructions about starting are given to the Chief Engineer, and when all is ready the engines are started ahead as slow as possible, and stopped the moment the line begins to tauten out; then a few more turns are made, and so on until the inertia of the tow is overcome and both ships are moving slowly with a steady tension on the line. The revolutions are then increased little by little and the course changed gradually, as may be necessary. When, finally, the tow is straightened out and moving steadily, the speed is worked up to that at which it is thought wise to continue.

In all changes of course, the tow puts her helm at first to the side opposite that of the leader, and so steers around into the leader's wake.

If the sea is such as makes it dangerous to tow to windward, it is worth while to consider whether a port cannot be made on a course which will present fewer difficulties, even if the distance is much greater.

After settling down to a steady rate of towing, the lines should be examined, springs hauled taut afresh, the strain divided as evenly as possible, chafing gear renewed wherever necessary, etc. Hands should be stationed night and day to watch the lines on both ships, with axes and unshackling tools ready for slipping hurriedly if necessary. It is well to have a light "messenger" line between the ships, for hauling messages across and for use in running a new line in case of necessity. This line should be left slack and should have ample length to allow for the fact that if the tow-line parts the leading ship will forge ahead considerably before she can be stopped. If such a line is not used, messages may be floated across by paying out and hauling in a light line like an old-fashioned log-line.

The towing vessel should use oil freely as in Plate 137.

Standard Towing Equipment, United States Navy.

All capital ships of the United States Navy carry the Standard Towing Equipment shown in Plate **146.**

The approved method of taking a vessel in tow is as follows:

Directions for Towed Vessel. Unshackle both bower cables at the five-fathom shackle, each anchor having first been secured by two housing-stoppers on the five-fathom shot. Reeve the free ends of the bower cables out through the bow chocks, bring them in on the forecastle and shackle them together, forming a bridle, taking care to have all clear for veering the bridle outside when ready.

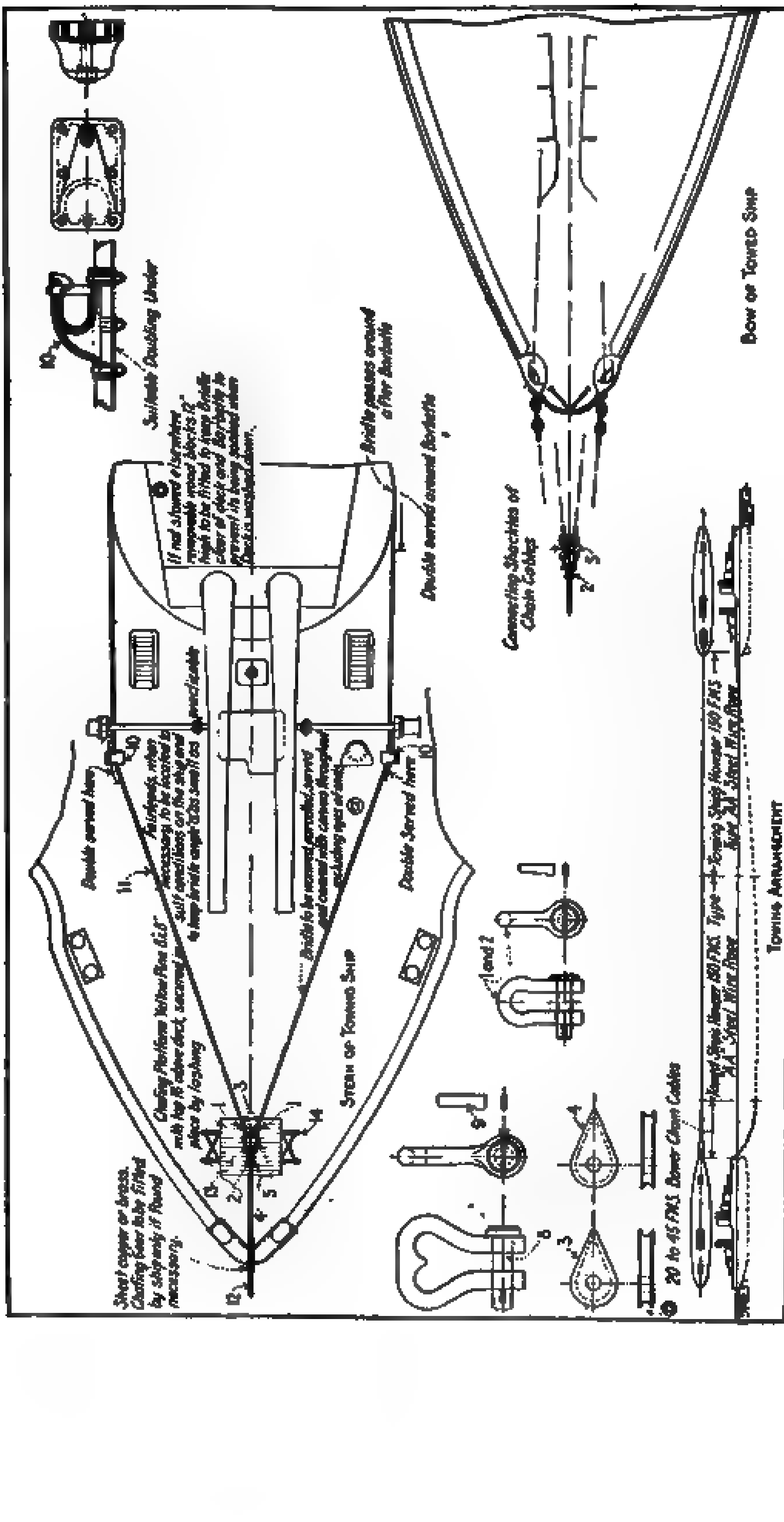
Shackle the end of the steel towing hawser to the bridle and flake the hawser on the forecastle, clear for running. Remember that the end which is shackled up to the bridle will go out last. Put check-stoppers of one-inch manila on the bights of the hawser to check it when it is payed out.

Bend a 3-inch manila line to a spar. Put the spar overboard and pay out the line. The spar will probably drift to windward; or, what amounts to the same thing, it will drift to leeward more slowly than the ship.

Directions for Towing Ship. Take position about one-half mile astern of the ship to be towed, and a little to windward. Secure the bridle around the turret. Flake down the towing hawser (2½-inch diameter wire), shackling one end to the bridle and the other to an 8-inch manila hawser, this hawser being also flaked down clear for running. To the free end of the 8-inch manila line bend one end of a 3-inch manila line which has been led aft from the forecastle, outside of all, and in through the stern towing chock.

All being ready on both ships, the towing ship steams slowly up to the spar,—the location of which is signalled by the towed ship—picks it up (on the forecastle) and bends the 3-inch manila line which the spar has floated across, to her own similar line leading from aft. The bight of the 3-inch lines is then thrown overboard, and the towed ship takes in the slack. When the line is clear of the screws of the towing ship she manœuvres to gain a favorable position, the 3-inch line being payed out as is found necessary by the towed ship. When a favorable position has been attained, the towed ship hauls in the 3-inch line, followed by the 8-inch, and finally by the end of the steel towing

Plate No. 146.



TOWING GEAR FOR BATTLESHIP UNITED STATES NAVY

hawser. The two towing hawsers are shackled together, and payed out. When the chain bridle is reached (on the towed ship) it is payed out carefully and the two cables are veered away to whatever scope is considered advisable. Sixty fathoms is recommended.

The precautions to be observed in starting ahead and in increasing speed have been detailed in an earlier part of this Chapter.

§ IV. TOWING ENGINES. TOWING ALONGSIDE.

Towing Engines. In the United States, vessels designed especially for towing are in most cases fitted with towing-engines, which carry the line on a reel and pay out and haul in automatically as may be necessary to keep the tension constant; the resistance of the tow being borne entirely by the steam pressure in the cylinders. If the tension on the hawser rises momentarily above this steam pressure, the drum revolves and pays out line. This action opens the regulating valve and increases the steam pressure in the cylinders until this pressure balances the tension on the line. If, later, the tension decreases, the steam pressure will be in excess and the drum will revolve and reel in the line, but at the same time the regulating valve will close in part, and the pressure will fall until it meets and balances the tension. In this way, the line is paid out or reeled in only just enough to meet the condition of things prevailing at any given moment, and the average length of line remains practically constant.

There can be no question of the enormous advantage in towing resulting from the use of these engines. A point of great, though perhaps secondary, importance, is that if the towing vessel stops, or if for any other reason the tow ranges up and slacks the line, the engine takes in the slack at once and keeps it clear of the screw. If it is found desirable at any time to shorten in the line, reducing the distance between the vessels, it can be done without difficulty. This may be important in passing around bends in a channel, or for taking in the line preparatory to casting off.

It is not the least of the advantages of the towing engine that it makes the use of wire-rope perfectly safe in all weathers.

Towing Alongside. When towing in port or in confined waters, the tug should be made fast alongside if possible, as this gives

greater ease and certainty in handling. When used in this way, the tug is usually placed on the quarter, where its rudder acts with that of the tow, for steering. As the power is applied at a distance from the midship line, there is here a considerable turning moment, which will throw the ship's head to one side or the other, according as the tug goes ahead or backs; the effect being exactly as if the ship had twin screws and was using only one of them. In going straight ahead, the turning effect is neutralized by a small amount of helm.

The tug must be made fast with a line from aft for going ahead and one from forward for backing. Both of these lines are usually made fast at the bow of the tug, her stern being held from swinging out by a breast-fast leading to the tow (Plate **122**).

If the tug has a right-handed screw, she will handle better if made fast on the port side; since, in backing, the tendency of her screw is to throw her stern out to port, while the tendency due to her position on the port side of the tow is to throw the stern of the tow the other way. Thus she will make a straighter sternboard than if made fast to the starboard side, where both these elements would tend to throw the stern off to port.

If, however, there is a sharp and difficult turn to be made, the tug should be on the inboard quarter; that is to say, on the side toward which the turn is to be made. Here she will be properly placed for *backing* to assist in the turn. So long as she is going ahead, she would be more favorably placed for turning, on the outboard side; but if her turning effect when so placed should prove insufficient for the turn she would be helpless. To back, under these circumstances, even for keeping clear of the beach, would only make matters worse. It is, therefore, the practice of tug masters to place themselves on that side of the tow toward which they wish to turn, *if the turn is one which involves some difficulty.*

It sometimes becomes necessary to turn the larger vessel on a pivot; that is to say, without going materially either ahead or astern. Suppose the tug is on the starboard quarter and wishes to slew the stern of the tow to port (Plate **117**). She lets go her stern breast and goes ahead with starboard helm,[2] holding on to the "go-ahead" line. This throws her stern out and she puts her bow (usually protected by a good fender) against the stern of the tow and pushes it around.

2. left rudder.

If it is desired to pull the stern to starboard, she lets go both lines from her bow, slacks the after-line, and swings off clear, going ahead as in Fig. 8. Observe that for this manœuver it is necessary that the line used for towing should lead from a point on the tug far enough forward of the rudder to let the tug's stern swing freely. She will then be able to head in any direction desired, even though there may be a current setting her down.

This is perfectly simple in the case of a tug whose towing bitts are placed well forward as is usual with tugs. In the case of a vessel not fitted in this way, the line may be taken through a side-chock fairly well forward, the vessel in this case being held up by the helm as in Fig. 2, Plate 148.

It sometimes happens that a vessel towing another alongside wishes to "wind" the tow to put her alongside a dock, the side on which the towing vessel is secured being the side which must be put to the dock. This is a manœuver which may be seen almost any day in a harbor like New York, where a tug, towing a barge and having the barge, say, on her starboard side, wishes to land the barge alongside a dock which is on the port hand, and at the same time to get herself clear of her position between the barge and the dock. Plate 117 makes it clear how this manœuver is performed. (But see description in Chapter XV.)

CHAPTER XXII.

RESCUING THE CREW OF A WRECK.

The situation here is somewhat like that where one ship is to take another in tow, but with several important points of difference. No matter how bad the weather may be, the work of rescue, if it is to be attempted at all, must usually be undertaken at once; and in practically all cases, by means of a boat. On the other hand, the rescuing ship is much freer to manœuvre than when she is hampered by lines as in making preparations for towing.

The natural way of proceeding under ordinary circumstances is to go to windward of the wreck and lower a boat, then go to leeward and stand by to pick it up. If oil is used along the weather side of the wreck, the boat will have an oil-slick, in addition to the lee afforded by her own vessel; and if the rescuing vessel uses oil after getting into position to leeward, the slick may be continued so that the boat shall have the benefit of it as she returns, loaded, before the sea. If for any reason the wreck cannot use oil, the rescuing vessel can steam around her, running oil freely and so creating a slick into which the wreck will presently drift.

If the weather is very rough, extreme precautions will be called for in lowering the boat and getting her clear. The ship should be held up with the sea on the bow, giving a lee for the boat and reducing the rolling as much as possible. The crew is lowered in the boat, with life-belts on. A painter is used from well forward, brought in on the inboard bow of the boat and tended with a turn around a thwart, and the steering oar is shipped in its crutch, ready to assist in sheering off clear of the side as soon as the boat is in the water. Frapping lines may be used around the falls to steady the boat, and sails or mattresses hung over the side as fenders, to prevent the boat from being stove if she swings in heavily. Two or three extra life-belts should be taken along, with two heaving lines bent to each. These are

for hauling back and forth between the boat and the wreck. Oil-bags should be hung from the bows of the boat.

As the boat strikes the water the falls are unhooked (after-fall first) and the painter passed quickly aft and hauled in, shooting the boat ahead and sheering her off at the same time. The vessel should be nearly dead in the water when the boat is lowered, but a little headway may be needed to keep her up to the sea.

Assuming that the boat gets off and makes the trip to the wreck in safety, the officer in charge must decide how he will establish communication and take off the passengers and crew. It is out of the question to go alongside to windward; and if he goes alongside to leeward, not only is there a risk of being stove by the wreckage which is likely to be found floating under the quarter, but there is the much more serious danger of being unable to get clear of the side again. As has been explained in the Chapter on Towing, a vessel lying in a seaway with engines stopped drifts to leeward at a rate which is always considerable and may amount to several knots an hour. A boat alongside such a ship, to leeward, is in exactly the same position as if she were alongside a dock against the face of which a strong current is setting. Every one knows how helpless a boat is under these conditions so far as getting clear is concerned. As a rule, then, the boat must never be brought actually alongside the wreck. She may either lie off to windward, being held up head to sea by the oars, or to leeward, holding on with a line from her bow to the wreck, with a few oars at work backing, to keep her at a safe distance, and at right angles to the keel line of the wreck. If obliged to go alongside, the stem may be allowed to touch, all being ready to back off if the boat shows a disposition to get broadside-on. It may be well to let the men at the oars face forward to make sure of being able to keep off. The people on board the wreck put on the life-belts, jump overboard one at a time, and are hauled into the boat. In most cases the most favorable point for working will be under the lee quarter or the lee bow, depending upon the way the wreck is lying with reference to the sea. It is sometimes possible for people to lower themselves or be lowered to a boat from the head-booms or from an overhanging main-boom, when they could not be rescued in any other way.

So serious is the question of avoiding actual contact with the wreck, that many officers consider it best for the rescuing ship

to go to windward and drop the boat down with a line, putting only two or three men in the boat. This is the plan recommended by Captains Todd and Whall in their Seamanship, and it is endorsed by a number of experienced officers who have favored the present author with their views; but a large majority of the officers who have written on this subject take the ground that a boat is always safer and more manageable with a full crew, and that to drop her down with a line from the ship simply hampers the manœuvring of both the ship and the boat without any sufficient compensating advantages. If proposing to drop the boat down with a line, it is important to make sure of having this of sufficient length. One end should be passed through the bow ring-bolt and hitched around a midship thwart. It is well to have fifteen or twenty fathoms of spare line in the boat for use when close to the wreck, as this gives the people in the boat control of the situation at the time when too much or too little may be of vital consequence. There should be three men in the boat (with life-belts on);—one man to handle the steering oar, one to handle the line, and one for bailing, signaling the ship, throwing the heaving line to the wreck, etc.—for there will be no moment during the rescue when either the steering oar or the line should be left unattended. A life-belt or buoy should be taken, in this case as in the one previously described, with two lines for hauling it back and forth between the boat and the wreck.

Oil-bags are hung from the quarters of the boat and oil used by the wreck, as in all cases of this kind. If the wreck cannot assist in this way, the rescuing vessel should pass along to leeward (at a good distance) running oil freely. The wreck will soon drift into the slick thus created.

The boat is dropped down by paying out line on board, being kept head to sea by the steering oar assisted by the drag of the line over the bow. The line must be kept in hand on board the ship, to insure a prompt response to signals from the boat. The officer in charge of the work keep his glasses on the boat incessantly.

If the line is led through a midship chock on the ship and the ship allowed to fall off on a heading parallel with the wreck, she will drift with the latter, though perhaps not at an equal speed, and will change the distance very slowly if at all. She will, moreover, be perfectly free to handle the engines slowly—going ahead

or backing as may be necessary to keep in position for giving the boat a lee. If the attempt is made to hold her up to the sea, it will be necessary to keep turning the engine ahead, which will result in drawing away from the wreck. There will, moreover, be constant danger of fouling the screw with the line, and no lee will be created for the boat.

A simple code of signals must be adopted and fully understood, thus:

In the Boat.

Right arm extended,	Slack away on board,
Left arm extended,	Haul in on board,
Arm held up overhead,	Hold on.

The arm waved, in either of these positions, emphasizes the order. Thus, the right arm extended and waved up and down means "slack away roundly."

On Board Ship.

A long blast of the whistle,	"We are about to haul in."

When the boat is near the wreck, say within thirty or forty yards, signal is made to hold on to the line on board, and the men in the boat begin to pay out, dropping down as close as is thought perfectly safe, then floating the life-belt across. This is picked up by those on board and worked as has already been described. When the boat is loaded, the signal is given and it is hauled back to the ship. Here the greatest care must be exercised and the line hauled in very slowly, else the boat is certain to be swamped.

If the weather is such that a boat cannot be lowered, the difficulties of effecting a rescue are greatly increased, but the situation is not necessarily hopeless. There are many ways of getting a line between the ships; as, for example, by a line-throwing gun, a rocket, or a float. If a balsa is available, the following method might give some hope: The rescuing vessel steams slowly across the stern of the wreck, towing the balsa by a very long line, and manœuvers in such a way as to cause the line (not the balsa) to foul the wreck. If the people on board can haul the

balsa up to leeward and get on it there should be no great difficulty about saving them.

Another method which suggests itself is the following: Suppose it is apparent that the wreck is drifting faster than the rescuing vessel will drift if she stops her engines. The rescuing vessel goes to leeward and places herself, with engines stopped, in such a position that her stern is just clear of the line of drift of the stern of the wreck, and with her head pointed away from this line, so that if any miscalculation is made, a few turns of the screw ahead will carry her clear. As the wreck drifts down, a line is gotten across by any means that is convenient and the people are hauled across. If the rescuing vessel drifts the faster she will of course go to windward instead of to leeward, and wait to drift into position herself. In this way it should be possible without imprudence to let the vessels come much closer than would be safe in any other manœuver that could be attempted.

The following extract from a letter received by the author gives a detailed description of several rescues by the writer of the letter, who is one of the most experienced officers of the International Navigation Company.[1] It will be noted that he believes in holding his ship as close as possible on the weather quarter of the wreck instead of going to leeward to pick up the boat; believing that more is gained by the lee afforded in this way than would be gained by the other plan.

In December, 1899, I was in charge of the boat from the S. S. *Pennland* that rescued the crew of the British Brigantine *Don Juan*, of Salcombe, England, in the North Atlantic. In the morning we discovered a vessel dismasted and rolling in the trough of the sea, the wind N.W., force about 7, and a very high sea. Getting closer to her, we saw that there were people on board of her. I got a volunteer crew and made the boat ready for lowering, taking in a couple of heaving lines, two buckets, and a large can of oil. The *Pennland* was brought to windward of the wreck close to and with the wind and sea about 4 points on the starboard bow, heading about west. The boat was lowered with the full crew, 8 men, in it and a bridle around the falls from the main deck to prevent the boat from swinging too much when lowered; a line from the fore part of the ship in the boat. The boat was lowered very quickly, and on touching the water the patent hooks disengaged themselves, the bow-line was passed aft and a strong pull on it brought the boat's bow around and

[1] Captain H. Doxrud, Steamship *Noordland*.

sheered it clear of the ship's side. We got the oars out immediately and pulled before the wind and sea toward the wreck, having good shelter of our own vessel. When we got close to the wreck we found it impossible to get alongside, as she was rolling heavily, the sea washing over her, and part of her rigging floating alongside. We got close under her stern with the boat and had a line thrown us from the wreck; to this we bent on our heaving line and a life-belt, which was hauled to the wreck, one end being in the boat. The life-belt was put on the first man to go and the bight of the line secured around him under his arms; he jumped overboard and was pulled in the boat. The life-belt was hauled back to the wreck, and by this means all the crew, 9 in number, were rescued. Our vessel was drifting in the trough of the sea with the wreck, close to; so a short pull brought us safely alongside.

During the rescue the boat's crew was placed as follows: two men in the bow to work the line, four men at the oars to keep the boat in position, one man bailing and myself steering (using a long oar instead of a rudder) and directing the work.

My second experience was in October, 1892, off the Flemish Cap—when Chief Officer of the S. S. *Noordland,* when I was in charge of the boat's crew that rescued the crew of the Norwegian Barque *Kong Oscar the 2nd.* The wind was N. W., force about 6, with heavy hail squalls. This rescue was very difficult and dangerous, as it was done during a very dark night, and took from 9 in the evening until 1 in the morning. The *Noordland* was brought to, to windward of the wreck, heading about west, when the boat was lowered in the same manner as on the former occasion, with 8 men in it. We got safely away from the ship's side. Coming up to the wreck, we found her waterlogged, the sea making a clean sweep over her, making it impossible to get alongside. The crew, numbering 16, was taken off by means of a life-belt and line, as on the former occasion.

The *Noordland* was drifting in the trough of the sea to windward, and we pulled up to her under her lee and got safely alongside and on board with our boat load of men. The boat's crew during the rescue was placed as on the former occasion.

My third experience was in October, 1899, when in command of S. S. *Rhynland.* When off George's Bank we fell in with the disabled and waterlogged British Brigantine *Ida Maud.* The night previous it had been blowing a gale from the S.E.; and at the time (about 3 P. M.), it was blowing from the N.W., force about 6, making a very nasty cross sea.

I brought the *Rhynland* to windward of the wreck, close to, heading about W.S.W., and lowered one of the port life-boats with a volunteer crew of 8 men, Chief Officer Daddow in charge. The boat got away from the ship all right and proceeded toward the wreck.

As on the former occasions, it was not possible to get alongside the wreck, the sea washing over her, and a lot of loose lumber floating about. A rope was thrown over the end of the main boom that extended several feet abaft the stern of the brigantine, the shipwrecked crew climbed out

one by one to the end of the boom and dropped into the boat. In the meantime I had brought the "Rhynland" close to the wreck, her bow nearly in line with the stern of the wreck, thereby giving the boat shelter, and a short pull brought them alongside.

In these instances oil has been frequently used both from the rescuing vessel, the boats, and in the first instance from the wreck also, and I cannot recommend its use too strongly for work like this. Its effect is simply wonderful, and I attribute my success in the above cases without mishap greatly to a liberal and judicious use of oil.

CHAPTER XXIII.

MAN OVERBOARD.

The most immediate danger to a man falling overboard from a steamer is that of being struck by the propeller. This danger is especially great in the case of a vessel with twin-screws, and is of course increased in any case by throwing the stern to the side on which the man has gone over.

If the experiment is tried of throwing over from the bow a light buoyant object, it will be found that by the time this reaches the stern it will be clear of the side by a considerable distance, being thrown off by the surface wash from the side. A *man* falling overboard may feel this wash to a certain extent, but he sinks in the beginning far below its influence and into the suction of the screw. Moreover, his first instinct is to swim back toward the ship.

The first thought of a man falling overboard should be to swim outward from the ship, and the first thought of the officer on the bridge should be to stop, *not back*, the engines. If it is known from which side the man has fallen, the helm may be put hard over to the opposite side, throwing the stern away from him. This calls for quick thinking and prompt action; but the time available is by no means as short as might be supposed. A steamer 400 feet long, making 12 knots, passes over her own length in twenty seconds. Thus, if a man falls overboard amidships, he will be ten seconds in reaching the screw.

One or more life-buoys should be thrown over at once. If a little presence of mind is exercised here, it is often possible to throw one of these very close to the man.

At the first alarm, a number of men (previously instructed), jump aloft to try to keep the man in sight; and as quickly as possible a quartermaster follows them with a good pair of binoculars.

The ordinary life-buoy is so small that often the man in the water cannot see it, and it is of little or no assistance to the

look-outs who are trying to keep him in sight. This is a serious and often a fatal defect. It is well to keep a number of these small light buoys about the decks, to be thrown overboard on the instant by any one who may be near them; but in addition to these, there should be provided a more elaborate buoy or float fitted with a mast and a light, to be let go promptly and to serve not only as a buoy, but as a *marker*.

If to this is added a can stuffed with oakum soaked in oil, a *slick* will be created around the buoy which will not only be of great help to the man but may assist greatly in keeping the spot in sight.

The light should be of a nature to ignite upon contact with the water. What is known as the "Holmes Light" is of this nature and is much used in the English merchant service. In the absence of a buoy fitted as above described (or in addition thereto), lights of this kind should be carried on the bridge (or forecastle), to be thrown over by the lookout, without an order, at the alarm of "Man overboard!"

This use of a marker, as distinct from the idea of a buoy (though preferably connected with the buoy) is of great importance.

Objection is sometimes made to the use of lights like the "Holmes" on the ground that the fumes given off by them are always offensive and in some cases unbearably suffocating. This is a reason for not connecting them rigidly with the buoy. They may, however, be attached to it by a short line which would let them float at some distance from it. Of course a light which ignites by contact with water must be sealed until it is wanted, when it may be punched or torn open either by a simple tool attached to it, as in the case of the "Holmes," or by some automatic arrangement connected with its release, as in the case of the U. S. Navy life-buoy.

Men-of-war usually carry life-buoys of special types, fulfilling more or less satisfactorily the above requirements. One of these is usually suspended on each quarter.

There seems no reason why a steamer should not carry at the end of the bridge (or on an outrigger if the bridge does not overhang the water), a small balsa, of a size sufficient to carry a man comfo tably, fitted with a mast and a light and with two or three water-tight pockets containing a small supply of provisions and water, and, perhaps, a few lights of the Holmes or some similar type which could be used to attract the attention of passing vessels, in the event of being left adrift.

Under ordinary circumstances the engines are thrown to full speed astern as soon as the man is clear of the screw, and a boat is lowered as soon as the speed has been reduced sufficiently. The boat pulls back in search of the man, guided by signals from the lookouts aloft, provided they have succeeded in keeping the man or the buoy in sight. Failing this, the boat cannot go far wrong if it pulls back on a course *opposite the original heading* of the ship; for although the steamer in backing will probably throw her head to one side, she will not usually gain a great amount of ground in that direction before coming to rest.

In most conditions of the sea, a boat may be lowered with reasonable safety at a speed of five knots; and we may assume that the distance required to reduce the speed to this will be from two to four ship's lengths, and the time, from two to four minutes.

If the weather is smooth or the sea from such a direction that there is no occasion for manœuvring to lower the boat, all this is simple enough; but if conditions are such as to call for *turning* wholly or partially before lowering, it is thought by many officers a good plan to put the helm hard over,[1] keeping the engines turning ahead, and to describe a circle, thus coming back, with the ship, to a point near that at which the man went over.

Observations upon the turning circles of a large number of steamers show that a steamer turning with hard-over helm[1] will pass within a short distance—rarely so much as a ship's length—from the point where the helm was put down. No doubt the symmetry of the curve may be considerably modified by wind and sea, but not sufficiently to prevent a return to the neighborhood of the starting point. The time required for the full turn will vary with the length, the speed, the weather and the manœuvring powers of the vessel. Every officer should know the manœuvring powers of his own vessel, especially the size of the turning circle, the time required to describe it, and how close the ship will come to a marker thrown over just before putting over the rudder.

Without attempting to lay down rules for the endless variety of situations which may arise in a matter of this kind, it will perhaps not be going too far to say that, generally speaking, the ship should be stopped and backed if she has the wind and sea ahead, or abeam, and that she would probably do well to turn, if they are much abaft the beam; since in the last case a boat pulling back would be working against wind and sea.

1. full rudder.

It will of course be understood that in turning, speed must be regulated according to the conditions of the weather. It would not do, for example, to come up into a heavy sea at full speed. (See Chapter "Handling a Steamer in Heavy Weather.")

If the conditions are such—due to the lack of a proper marker, or to fog, or to any other cause—that difficulty is to be anticipated in finding the man, it is probably better to stop and send the boat back along the course opposite the original heading. This emphasizes the importance of having a compass in the boat.

In case of fog, the vessel should avoid changing her position while the boat is away. The compass is thus a guide for finding the way back—assisted, of course, by sounding the whistle, firing guns, etc.

There can be no question that in weather too heavy to admit of lowering a boat, the one method that can give a hope of saving the man is to turn and attempt to pick him up with the ship.

In squadron. Special rules are laid down for cases of man overboard in squadron. It may be assumed that all officers concerned are familiar with these. Generally speaking, they provide for the necessary manœuvers to keep clear of other ships while picking up the man and for the signals notifying other ships of the situation.

They also direct what steps shall be taken by neighboring ships to assist in the rescue. Except when the ships are in column, the actual manœuvers on the part of the vessel losing the man are not greatly different from what they would be if she were acting singly, although in certain formations there might be difficulties connected with turning.

See "Man Overboard" in Chapter XX.

CHAPTER XXIV.

STRANDING.

§ I.

The first impulse of an officer upon finding his vessel stranded is usually to throw the engines to full speed astern. This may be the right thing to do, but it is not always so. If the ship has struck a rock, the chances are that she will have a hole in her bottom, and to back off may result in sinking her without leaving time even for saving life. If aground on a soft bottom, to work the engines either way may result in disabling them by filling the condensers with sand or mud. Again, where a single-screw steamer is aground forward, backing the screw may slew her stern around and put her on the beach throughout her full length. These are points which should be taken into consideration in deciding whether or not to back the engines immediately.

Assuming that, for whatever reason, it proves that the vessel cannot be backed off at once, the most urgent step to be taken is to lay out an anchor and get a good strain on a line from this, for holding the ship from being set farther up on the beach. Such a line, kept well taut, will sometimes start a ship off quite unexpectedly by the steady pull which it exerts;—a slight rise of the tide or a little working of the ship by the wind or sea, contributing toward the same end. As the laying out of a large anchor involves delay when every moment may be precious, it is well to send out a kedge at once, following this as soon as possible with a stream or a bower. If there is a current setting along the coast, as frequently happens, the anchor should be laid out a little off the quarter, to keep the stern from being swept around. A buov with a good buoy-rope should be used on the anchor. (See Chapter X, *Carrying Out Anchors.*) While this work is in progress, careful soundings should be made around the ship on all sides, and a good leadsman stationed to note the rise or fall of the tide. The Tide-Tables, Sailing Directions, and Charts will of course be examined, the time of high water

determined, and the direction of tidal currents noted. If there is a chance that help will be needed, no time should be lost in communicating with shore and making such arrangements as the situation calls for. The immediate assistance of a vessel large enough to carry out a heavy anchor may be of the greatest value. It may be possible to secure a fishing vessel for this. If a tug can be secured, this may be the best use that can be made of her in the beginning.

An examination of the ship should be made as soon as possible after she strikes, and all compartments sounded. As already noted, this is particularly important on a rocky coast. If a compartment is found to be holed, the water-tight doors leading to it should be closed, the bulkheads braced, and the pumps put on, to keep the water down. If the hole is a large one, there will probably be danger in hauling off before stopping it at least in part.

When measures have been taken to prevent the ship from being set farther up the beach, *and not until then,* the work of lightening her may be begun;—ballast tanks pumped out, cargo shifted, lightered, or thrown overboard. If the ship is aground forward, something may often be gained by filling the after ballast tank or otherwise adding weight aft; as, for example, by shifting coal from an extreme forward to an extreme after bunker.

Getting out the boats is a quick and simple way of lightening the ship. They may be filled at once with provisions and other stores of such a nature as to be handled quickly, these being taken first of all from the forward holds—assuming the ship to be aground forward. If the beach is near, this freight may be landed and the boats brought alongside to be loaded again.

A man-of-war, with a large crew and plenty of boats, should be able under these circumstances to get rid of several hundred tons of easily handled stores within an hour or two. At the same time, the work of shifting weights from forward to aft can be going on, those articles being chosen first which lend themselves to "man-handling," such as boxes of provisions, bales of clothing, ammunition (except very heavy projectiles), cordage, etc. Much is gained if the conditions admit of letting go the anchors immediately and paying out the cables. This alone, if quickly done, might suffice to float a ship which was only lightly aground

well forward. But this will be dangerous if there is any chance of the ship being driven farther up so that she may strike on the anchors. It is a good rule in any case of letting go an old-fashioned anchor when aground, to unstock it and foul the flukes with several turns of cable.

All water in tanks forward should be pumped overboard. Nor should it be forgotten that five hundred men assembled aft gives a weight of approximately seventy-five thousand pounds to help lift the bow.

When conditions become favorable for backing and hauling off—which will of course be at high water—the chances of success will be greatly increased if the ship can be moved in her bed, either by rocking her from side to side or by slewing her stern a little. This may perhaps be done by means of a line to an anchor laid out on the beam or quarter.

Vessels have been worked loose from a sandy bottom by *going ahead* with their engines; the suction current drawing aft along the bilge acting apparently to scour out the sand.

If another vessel comes to your assistance, she should, as a rule, anchor to seaward of you, with a good scope of chain, get good lines from your stern, and heave these taut until she tails in toward you or as nearly so as the wind and tide permit. If she then starts her anchor windlass ahead and keeps full steam pressure on it, she will not only keep the lines taut, but will take in and hold every inch that is gained on the line between the ships. When the time comes for a combined effort to haul off, she starts her engines ahead, still keeping the anchor windlass in action.

It is a good plan for the assisting vessel to lay out her own spare anchors well off shore with good lines bent to them, and to send the ends of these lines on board the stranded vessel. These will be heavier than the anchors that the stranded vessel could conveniently lay out for herself, and can be placed to far better advantage. This does not interfere with any of the other methods of assisting that have been described.

In cases where a strong current runs along the beach at certain stages of the tide, if the lines are hove taut at slack water, the current when it makes will be on the beam of the anchored vessel and will exert a tremendous force, with all the advantage due to the span formed by the anchor-cable and the tow-line. It would

be well here for the assisting vessel to have two anchors down, and to substitute a bower-cable for the hawser between the ships. Plate **148**.

In all cases like the above, of attempts to pull a stranded vessel off, there is danger that if she comes off suddenly she will collide with the vessel that is assisting her. The latter should therefore be ready to slip everything and get out of the way.

There is one possible advantage which results from having the towing ship under way. This is that if she does not start the other vessel by pulling directly astern, she can place herself on the quarter and may thus be enabled to slew the stern of the stranded vessel and so loosen her up in her bed.

Generally speaking, however, the difficulties are increased if the assisting vessel cannot anchor. It is almost impossible for her to keep a steady tension on the line, under the most favorable circumstances; and if the wind or the current is across, there is great danger that she will swing around on the tow-line and end by going ashore herself.

See Chapter on Piloting, where it is explained that in many places the full strength of tidal current corresponds with high and low water.

The only thing to be done where the assisting vessel cannot anchor is for her to lie off, head to the current, until all is ready; then to run the line, *taking it from one of her own chocks fairly well forward*—not under any circumstances from the stern. She then heads more or less across the current and goes ahead, putting the strain on the line gradually and holding herself up against the tide by the helm, which will have good turning power because of the way the ship can pivot on the line (Plate **147**, Fig. 4). With the line led through a stern chock, the rudder would have no power, and the ship would be swept down helplessly toward the beach unless she cut the line. Even when manœuvring as above described, an axe should be at hand to cut if necessary.

If the draft of the assisting vessel permits her to go alongside she should be placed with her stern to the beach. If her bower anchors are laid out and her anchor engine kept running, this may be a powerful help. It may happen, too, that the current

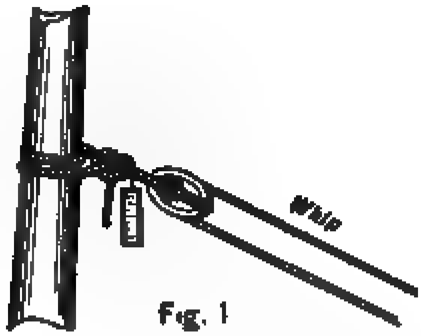


Fig. 1
Tail Block Hauled
off by first line from shore

Fig. 2
Hawser Hauled off by Whip

Breeches Buoy.

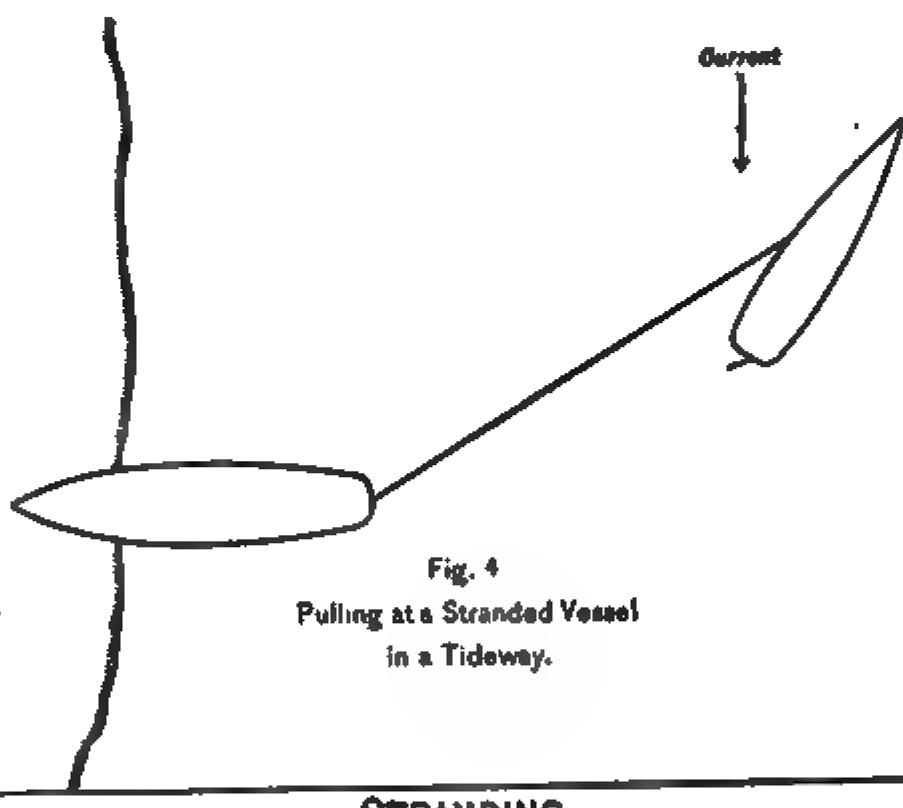
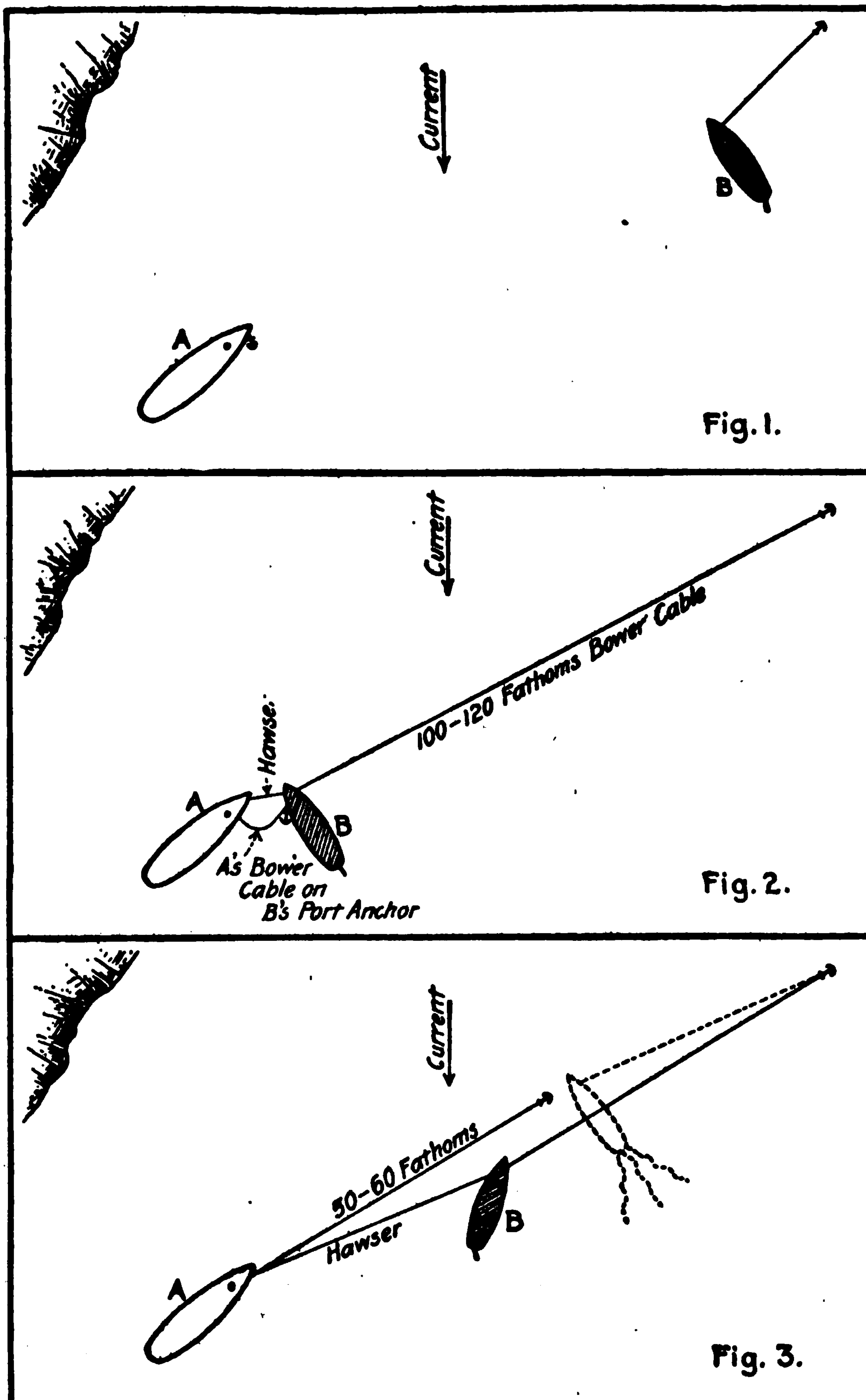


Fig. 4
Pulling at a Stranded Vessel
in a Tideway.

STRANDING

Plate No. 148.



HAULING OFF A STRANDED VESSEL.

from her screw, going ahead with full power, will scour out the bottom under the stranded vessel.

There are, of course, many cases in which the effort to back off should be made immediately; as, for example, when it is known that the beach on which the ship has struck is hard and steep and not rocky. Here she will certainly be aground forward only, but there is great danger that she will swing around and ground throughout her whole length. And if this does not happen, the chances are that if there is any sea on she will be dangerously strained and perhaps broken in two. So here the one chance may be to back at full speed immediately;—not, however, neglecting other measures which do not interfere with it. If it is found that the backing is slewing her around broad-side-on, the engines must be stopped. This is very likely to happen with a single screw. On a beach of this kind, it is particularly important to get an anchor laid out immediately. A light kedge carried out at once on the quarter opposite that toward which she is inclined to swing around, may be of vital importance.

If all other methods fail, resort must be had to regular salvage operations, the description of which is beyond the scope of this book.

The following plan is recommended by an officer of long experience, as especially valuable in cases where a vessel is stranded on a muddy or sandy bottom (not rocky) and where another vessel goes to her assistance:

Referring to Plate **148**. *A* is aground, and *B* goes to her assistance. *A* being on the left side, facing the current, *B* drops her starboard bower anchor at a distance from *A* not exceeding her available scope of cable, and goes ahead with helm a-starboard,[2] keeping the current on the starboard bow and allowing herself to be set over toward *A* until she is as close as is practicable, which will of course depend primarily upon her draft. *A*'s starboard bower anchor is now transferred to *B*'s port bow, if this can conveniently be done, by boats or otherwise; or, more simply, *A*'s starboard bower cable is unbent and the end is hauled across and shackled up to *B*'s port bower chain, disconnected at a convenient shackle.

At the same time a good hawser is run between the ships. If this hawser is run immediately, it will help to hold *B* in position

2. left rudder.

while getting the chain across and may save some troublesome manœuvering in quarters perhaps uncomfortably close. Fig. 2.

Everything being ready, *B* starts her steam-windlass and heaves in her starboard cable, using her screw as before, but this time with the current on the port bow and more nearly ahead than before.

A, in the meantime, veers away her starboard cable, which is thus laid out by *B*. Fig. 3.

When *A's* cable is all out, or when no more of it can be laid out, *B* lets go the anchor and *A* heaves in on her cable, and makes fast the hawser connecting with *B*. At the same time, *B* heaves in on her steam windlass, and goes ahead with her screw. Thus we have the windlasses of both ships pulling on *A*, with the power of *B*'s screw added, and, still further, the "sucking" effect of the current acting on *B*'s port bow, and, provided *A*'s bow yields enough to cant her, acting on *A* as well.

§ II. INSTRUCTIONS TO MARINERS IN CASE OF SHIPWRECK.

All sea-faring people should be familiar with the following instructions, which are practically identical with those issued by all nations having Life Saving Services. It is the unanimous testimony of the employees of such services that the principal difficulties with which they have to deal arise from the failure of shipwrecked crews to cooperate intelligently in the work of rescue.

INSTRUCTIONS.

Rescue with the Life-Boat or Surf-Boat.

The patrolman, after discovering your vessel ashore and burning a Coston signal, hastens to his station for assistance. If the use of a boat is practicable, either the large life-boat is launched from its ways in the station and proceeds to the wreck by water or the lighter surf-boat is hauled overland to a point opposite the wreck and launched, as circumstances may require.

Upon the boat reaching your vessel, the directions and orders of the keeper (who always commands and steers the boat) should be implicitly obeyed. Any headlong rushing and crowding should be prevented, and the captain of the vessel should remain on board, to preserve order, until every other person has left.

Women, children, helpless persons, and passengers should be passed into the boat first.

Goods or baggage will positively not be taken into the boat until all are landed. If any be passed in against the keeper's remonstrance he is fully authorized to throw the same overboard.

Rescue with the Breeches-Buoy or Life-Car.

Should it be inexpedient to use either the life-boat or surf-boat, recourse will be had to the wreck-gun and beach apparatus for the rescue by the breeches-buoy or the life-car.

A shot with a small line attached will be fired across your vessel.

Get hold of the line as soon as possible and haul on board until you get a tail-block with a whip or endless line rove through it. This tail-block should be hauled on board as quickly as possible to prevent the whip drifting off with the set or fouling with wreckage, etc. Therefore, if you have been driven into the rigging, where but one or two men can work to advantage, cut the shot-line and run it through some available block, such as the throat or peak-halliards block, or any block which will afford a clear lead, or even between the ratlines, that as many as possible may assist in hauling.

Attached to the tail-block will be a tally-board with the following directions in English on one side and French on the other:

"Make the tail of the block fast to the lower mast, well up. If the masts are gone, then to the best place you can find. Cast off shot-line, see that the rope in the block runs free, and show signal to the shore."

The above instructions being complied with, the result will be as shown in Fig. 1, Plate **147.**

As soon as your signal is seen a three-inch hawser will be bent on to the whip and hauled off to your ship by the life-saving crew.

If circumstances will admit, you can assist the life-saving crew by manning that part of the whip to which the hawser is bent and hauling with them.

When the end of the hawser is got on board a tally-board will be found attached, bearing the following directions in English on one side and French on the other:

"Make this hawser fast about two feet above the tail-block, see all clear and that the rope in the block runs free, and show signal to the shore."

These instructions being obeyed, the result will be as shown in Fig. 2, Plate 147.

Take particular care that there are no turns of the whip-line round the hawser. To prevent this take the end of the hawser UP BETWEEN *the parts of the whip before making it fast.*

When the hawser is made fast, the whip cast off from the hawser, and your signal seen by the life-saving crew, they will haul the hawser taut and by means of the whip will haul off to your ship a breeches-buoy suspended from a traveler-block, or a life-car from rings, running on the hawser.

Fig. 3, Plate 147, represents the apparatus rigged, with the breeches-buoy hauled off to the ship.

If the breeches-buoy be sent, let one man immediately get into it, thrusting his legs through the breeches. If the life-car, remove the hatch, place as many persons into it as it will hold (four to six), and secure the hatch on the outside by the hatch-bar and hook, signal as before, and the buoy or car will be hauled ashore. This will be repeated until all are landed. On the last trip of the life-car the hatch must be secured by the inside hatch-bar.

In many instances two men can be landed in the breeches-buoy at the same time by each putting a leg through a leg of the breeches and holding on to the lifts of the buoy.

Children, when brought ashore by the buoy, should be in the arms of older persons or securely lashed to the buoy. Women and children should be landed first.

In signaling as directed in the foregoing instructions, if in the daytime, let one man separate himself from the rest and swing his hat, a handkerchief, or his hand; if at night, the showing of a light, and concealing it once or twice, will be understood; and like signals will be made from the shore.

Circumstances may arise, owing to the strength of the current or set, or the danger of the wreck breaking up immediately, when it would be impossible to send off the hawser. In such a case a breeches-buoy or life-car will be hauled off instead by the whip, or sent off to you by the shot-line, and you will be hauled ashore through the surf.

If your vessel is stranded during the night and discovered by the patrolman, which you will know by his burning a brilliant red light, keep a bright lookout for signs of the arrival of the life-saving crew abreast of your vessel.

From one to four hours may intervene between the burning of the light and their arrival, as the patrolman will have to return to his station, perhaps three or four miles distant, and the life-saving crew draw the apparatus or surf-boat through the sand or over bad roads to where your vessel is stranded.

Lights on the beach will indicate their arrival, and the sound of cannon-firing from the shore may be taken as evidence that a line has been fired across your vessel. Therefore, upon hearing the cannon, make strict search aloft, fore and aft, for the shot-line, for it is almost certain to be there. Though the movements of the life-saving crew may not be perceptible to you, owing to the darkness, your ship will be a good mark for the men experienced in the use of the wreck-gun, and the first shot seldom fails.

Recapitulation.

Remain by the wreck until assistance arrives from the shore, unless your vessel shows signs of immediately breaking up.

If not discovered immediately by the patrol, burn rockets, flare-up, or other lights, or, if the weather be foggy, fire guns.

Take particular care that there are no turns of the whip-line round the hawser before making the hawser fast.

Send the women, children, helpless persons, and passengers ashore first.

Make yourself thoroughly familiar with these instructions, and remember that on your coolness and strict attention to them will greatly depend the chances of success in bringing you and your people safely to land.

The following signals, approved by the International Marine Conference convened at Washington in October, 1889, have been adopted by the Life-Saving Service, and will be used and recognized by the officers and employees as occasion may require:

" Upon the discovery of a wreck by night, the life-saving force will burn a red pyrotechnic light or a red rocket to signify—'You are seen; assistance will be given as soon as possible.'

"A red flag waved on shore by day, or a red light, red rocket, or red Roman candle displayed by night, will signify—'Haul away.'

"A white flag waved on shore by day, or a white light slowly swung back and forth, or a white rocket, or white Roman candle fired by night will signify—'Slack away.'

"Two flags, a white and a red, waved at the same time on shore by day, or two lights, a white and a red, slowly swung at the same time, or a blue pyrotechnic light burned by night, will signify—'Do not attempt to land in your own boats. It is impossible.'

"A man on shore beckoning by day, or two torches burning near together by night, will signify—'This is the best place to land.'

"Any of these signals may be answered from the vessel as follows: In the daytime, by waving a flag, a handkerchief, a hat, or even the hand; at night, by firing a rocket, a blue-light, or a gun, or by showing a light over the ship's gunwale for a short time, and then concealing it."

CHAPTER XXV.

HINTS FOR JUNIOR OFFICERS DOING LINE DUTY.[1]

ASSIGNMENT.

Junior officers "shall perform such duty as may be assigned them"; and this duty may include the following: Officer commanding, or junior officer of, a gun, torpedo, or powder division; together with that of—

(1)	(2)
Officer of the deck,	Assistant to the executive,
Junior officer of the deck,	Assistant to the navigator,
Officer of the forecastle,	Mate of deck, or hull and hold,

or a combination of one of the duties named in column (1) with one of those named in column (2). Engineering duties are omitted from the list given above as they are not within the scope of this chapter.

DUTIES OF OFFICERS ATTACHED TO GUN DIVISIONS.

By far the most important duties under this heading are those connected with target practice and the care of the battery. These may be found in detail in "Gunnery Instructions, U. S. Navy," and in the "U. S. Navy Regulations." Notes containing the results of others' experience may be found in "Reports of Target Practice."

Beside the information and data required by the "Gunnery Instructions," and a copy of the ship's bills, every division officer and junior division officer should keep a book containing the watch, quarter, and station bills for his own division which should be more detailed than the bills kept in the executive officer's office, since they must include individual stations for every man in the division, and other information not contained in the ship's bills. This book must be kept up to date. To keep it so requires little work if attended to immediately, but causes much

[1] By Lieut. B. B. Wygant, U. S. Navy. Reproduced by kind permission of U. S. Naval Institute.

trouble if neglected. The executive officer notifies the officer concerned of the changes made, but as a precaution, the division book should be compared frequently with the bills in the executive officer's office. The division book contains the following information, either in the form given, or in some other similar form.

(1) A list of the men in the division arranged by sections and after each, his

Rate (actual).
Rate (allowed by complement).
Gun (number and caliber).
Fire station.
Collision station.
Detail at embarkation of landing force.
Fire and rescue station.
Coaling station.
Station for getting underway (if specially detailed).
Station for anchoring (if specially detailed).
Cleaning station.
Brightwork station (gun and deck).
Hammock number.
Billet number.
Pay number.
Boat (running and abandon ship).
Mess.
Hammock netting.
Bag rack.
Ditty-box rack.

(2) A list of the men in the division arranged by gun crews and ammunition crews, and after each, his

Title.
Station.
Duty at "cast loose and provide."
Duty at "secure."
Gun brightwork.

(3) A list of the men in the division arranged by boat crews, and after each, his

Station for lowering.
Articles to supply at "abandon ship."
Thwart.
Boat brightwork.

(4) The general bills for the division, viz.:
Fire bill.
Collision bill.
Landing-force bill.
Fire and rescue bill.
Coaling bill.
Cleaning bill, including compartments below, and double bottoms.
Brightwork bill.

To (3) must be added, after the boat crews, a list of the additional men assigned to the boats at "abandon ship," and what each one provides.

After making out a division book, an officer should inspect the ship thoroughly, familiarizing himself especially with the steering gear, including methods of shifting from one system to another; the anchor gear, including location of compressors, controllers, and the management of the anchor engine; the fire-main system, including the location of all plugs and risers; the drainage system, including the location of pumps and manifolds; the system of internal communications, including fire-control system, voice tubes and telephones; the location of W. T. door and general alarm keys; and the bunker and magazine fire-alarm indicators.

The importance of making this a thorough and minute inspection cannot be overestimated. If properly done it will take several days, and should be so complete that it will never be necessary to ask, for example, of someone in the carpenter's gang, "How turn the water on in the ash chute?" or of the quartermaster, "Where are the spare sounding tubes stowed?"

The following data and any other that is deemed of enough importance should be memorized:

Ship's length over all, and on water line.
Ship's beam.
Ship's draft.
Ship's armor and armament.
Number and stowage of boats.
Height of trucks, tops, and bridges.
Number and arrangement of boilers and engines.
Number and arrangement of dynamos.

After the general inspection of the ship should come a detailed inspection of that part of the ship, the battery, and the magazines assigned to his own division. For these inspections and future work about the battery, a couple of suits of dungarees are indispensable. Blue prints of the ship may be obtained from the executive officer or carpenter, and of the battery from the ordnance officer or gunner.

An officer assigned to the powder or torpedo division will have to modify his division book from the form given above, but this modification will be slight.

STANDING WATCH.

The general duties before taking charge of the deck, and the duties and the responsibilities afterward are stated in the "U. S. Navy Regulations." To dwell on the importance of a thorough knowledge of these to a naval officer is unnecessary. One might as well tell a preacher to learn the ten commandments; but there are so many times in the experience of a young officer, when, in spite of a thorough knowledge of the Regulations, he may be at a loss as to the proper and customary procedure, that it is hoped the following remarks in amplification and explanation will not come amiss.

These notes, though applying principally to the officer of the deck, apply also to the junior officer of the deck in so far as his authority extends, and it must be borne in mind that the only way for the junior officer to acquire a "watch and division" is to show that he is competent to perform, and possesses a knowledge of, the duties that will devolve on him when entrusted with that responsibility.

Before coming on watch the officer should provide himself with a notebook and pencil, unless one is regularly provided by the executive officer for that purpose. It is useful in taking down verbal orders and as an aid to the memory in noting occurrences for the log, etc.

In relieving, one should *never be a second late*. It is a matter of pride with good watch officers to relieve at the stroke of the bell.

The relief goes to the officer of the deck, wherever the latter may be, and says, "I am ready to relieve you, sir," waits until all necessary information has been turned over to him, and when satisfied, says, "I relieve you, sir." The Regulations specify under what circumstances an officer may decline to relieve and the procedure to be followed. It is customary for an officer not to allow himself to be relieved during an evolution. The officer on watch turns over to his relief whatever information he possesses, and should give him any hints that might help in carrying on the next watch. In the days of sailing ships it was considered most uncomplimentary for a relief to alter the trim of the yards or make any new disposition of sails within a half hour after relieving, except of course in a case of emergency

Before Relieving at Anchor.

The following information should be obtained before relieving: Bearings of anchorage; depth of water; what anchor is down, and how much chain out, including the location of shackle or mark, thus, "30 fathoms at the water's edge," "45 fathoms inside," "60 fathoms abaft the bitts," and how secured; state of tide and time of last swinging; if moored, whether ship swung to port or starboard last, and state of hawse as far as is known; condition of engines and boilers; what boats are down, and what ones are out of commission on account of fresh paint or for other reason; landing to be used by ship's boats; what officers are ashore on duty or otherwise; what working or liberty parties are ashore; number of prisoners and how confined; whether there are any visitors aboard, and if officers, naval, military, or civil, what honors were given on their arrival; unexecuted orders and the state of the work going on; condition of awnings, and whether there are any wash clothes or scrubbed canvas on the lines; state of weather during preceding watch; prescribed uniform; and any other information likely to prove useful. At night in addition, the officer relieving should find out what boat or boats have been prepared as lifeboats; where the anchor watch billets are; and where the following men sleep, chief (or other) master-at-arms, chief (or other) boatswain's mate, blacksmith (or whoever tends anchor engine), and bugler.

After Relieving at Anchor.

If practicable, the officer of the deck should inspect the upper decks soon after coming on watch, and at intervals during his watch. He should make good any deficiencies in the information required above, and should obtain the following: Which direction the chain is tending; whether or not the buoy is watching; general condition of wind, weather and barometer; whether boats are riding properly, are clear of side, and the boatkeepers alert and sitting up in the boats; whether ventilators and windsails are properly trimmed; whether accommodation ladders are properly triced up (clear of the water if rough); whether boat lines are rigged (if necessary) and the ends coiled down on the upper platform. He should see that the boatswain's mate, the quartermaster, the signalmen, the messengers, and the sideboys (if needed) are at their stations and alert. In the daytime he should see that the booms, guns and ports are squared; that the colors and pennant are chock up and clear; that awnings are properly spread on the ship and in the boats, and no stops or earings hanging down; that no clothes are hanging in unauthorized places; that all is taut aloft and the deck kept clean; and that work is going on as ordered. At night he should see that the proper lights are lighted and burning brightly, and that no others are showing; that no men are sleeping on the engine and dynamo-room hatches, and that no clothes are hanging in them; that awnings are housed and signal halliards slack; and that no unauthorized persons are about the deck.

If Moored to Dock.

In addition to whatever applies under the heading "at anchor," the officer of the deck on a vessel moored to dock should inspect chain and rope fasts to see that they are not too taut at high and low water, and that rope fasts have chafing gear where needed; should see that brows and spurshores do not get slewed, and should watch the camels and prevent their capsizing as the tide rises and falls.

Before Relieving Underway.

Read the order books. If on soundings or near land, have a look at the chart before reporting your readiness to relieve. The following information is obtained before relieving: Course p. s. c., and by steering compass; speed and number of revolutions of the screw, together with any recent changes; formation, distance, and interval; landmarks, vessels, and buoys in sight; position of ship on chart; condition of anchors, bucklers, and ports; condition of weather during previous watch; and whereabouts of the commanding officer. At night in addition, the following: condition and location of "stand by" oil lights. In foggy or thick weather: Whether blank charges for signal gun are at hand, and competent man to fire same standing by; whereabouts of position buoy and whether ready for use. The night order book (captain's), and morning order book (executive officer's), should be turned over by the officer going off duty in person, if in his possession, and he should particularly inform his relief if there is anything out of order with any means of communication, or with any of the alarm signals.

Remember that the fact that something was not "turned over" does not always excuse ignorance, notably in cases where the officer on watch is in a position to ascertain the facts after relieving.

After Relieving Underway.

First verify the ship's position with regard to other ships, and if in pilot waters with regard to the plotted position on the chart, and see that soundings are being taken if necessary; then verify the course by standard and steering compasses; see that the breakdown flag is rounded up and the halliards clear; ascertain whether your ship conforms to the flagship in the following particulars: number of speed cones hoisted, station of lookout, and size of ensign displayed; have quartermaster, boatswain's mate, messengers, cone or speed-light boys, bugler (during daytime), and lookouts, at their stations and alert; see ventilators and windsails trimmed; have boatswain's mate inspect position buoy if used; have leadsmen detailed when the watch is mustered, if on, or soon to be on, soundings, and in latter case let the boatswain's mate report the platforms or aprons rigged and the leadlines clear

after he has satisfied himself on that score; see that guns, ports, and cranes are squared. At night, satisfy yourself that the running and speed lights are burning brightly, and make certain that the searchlights are ready for use.

Keeping the ship in her proper position with regard to other ships in formation, which is probably the most important duty that a watch officer is called upon to perform, can only be learned by experience, but one or two suggestions may be given. Unless absolutely necessary, or in performing an evolution, use very little helm, otherwise the ship will yaw far out of position, and the speed of the ship be considerably slowed by the hard-over helm.[1] Send as few signals to the engine-room as possible, and have enough confidence in your judgment to give each change a chance to act. Remember that it takes some time after the signal is sent for the engines to steady down to the new speed, and still longer for the change in the number of revolutions to affect the speed of the ship. In changing speed allow for the inertia of the ship and try to anticipate the result of a change; i. e., suppose the ship is ahead of her position and losing distance, don't wait until you are just 400 yards from the next ahead and then resume the standard number of revolutions, but ring up a few turns before that time and try to arrange it so that the speed of the *ship* will just have steadied down to standard as the distance is correct.

The officer of the deck on a ship in formation has to give most of his attention to matters outside of his own ship and sometimes the carrying on of the routine is delegated to the junior officer of the deck, in which case it behooves the latter to follow the instructions given above.

THE DAY AT ANCHOR.

The Morning Watch.

When one is to have the morning watch it is advisable to read over the morning orders the previous evening, so that any explanation desired may be obtained beforehand, and the necessity will not arise of awakening the executive officer at "all hands," for some matter of trifling importance.

Read over the morning orders upon relieving, and get the sequence of events fixed in your mind. Probably the first thing

1, full rudder.

to be done will be to get up steam in the running steamer. See that the machinist or coal passer is called and has fires started in time to get up steam, with a margin for unforeseen difficulties. 45 to 60 minutes from lighting fires to steam at 100 lbs. pressure is ample under ordinary conditions. Of course, if the coxswain has been given orders about getting up steam, he is responsible, but that doesn't help the officer of the deck if the boat is late getting alongside, and the latter, while holding the petty officers to a strict accountability, must always keep a close supervision over what is going on, as after all it is he who is blamed if anything goes wrong. In some fleets, at five minutes before sunrise, the flagship turns on " F " as a warning to stand by the anchor lights. Have whoever is detailed, usually quartermasters, signalmen, or electricians, ready to turn out lights as " F " is extinguished. At time indicated on routine, call masters-at-arms, boatswain's mates, bugler, and hammock stowers. It is easy enough to tell the quartermaster to call these men, but getting them up on time is another matter. The petty officers, as a rule, give no trouble, but the junior officer of the deck will probably have to see to the hammock stowers himself. As the hammocks come up notice whether they are properly lashed, and if not, have them mended. At the end of the time allowed, the master-at-arms reports that all hammocks are off the lower decks. The routine usually requires mates of decks and warrant officers not having a night watch to be called at "all hands." From that time until "turn to" is, under normal circumstances, allowed for coffee and smoking. Unless necessary don't intrude work on this time. At "turn to," if clothes or canvas are to be scrubbed, have the word passed, and if for any reason more or less time than usual is to be allowed before the lines are to be triced up, let the men know so that they can bring up the proper number of pieces to scrub. Before wetting down have the deck swept, and see that the petty officers in charge of parts of the ship allow no man to start scrubbing on a dry deck, as soap-suds under these conditions cause white spots to appear when the deck is dried down, and these spots are very hard to remove even with sand. Have the hose connected and the water turned on promptly, so that the men may have the full time allotted for scrubbing. A half hour is the usual time allowed for this, and about ten or fifteen minutes more for stopping them on the line.

See that the petty officers in charge of parts of the ship allow no scrubbing after the word is passed to knock off. The junior officer of the deck can help in this. Blue clothes should be stopped on the line to leeward, or below if on the same line. Avoid holidays. The boatswain or chief boatswain's mate usually looks out for this. When fresh water is served out, see that the master-at-arms and the captain of the hold are ready in time to prevent delay. About this time the first market boat leaves the ship. If an officer is to go, have him called in time. Notify all stewards, and have those that are going on deck ready to jump into the boat when she comes alongside. Before shoving the boat off, state distinctly at what time the next market boat leaves the shore. Remember in calling away this boat, that it takes longer to get a boat alongside the first time it is called away, on account of time taken up in casting off the stern line and getting water out of the engine if a steamer, or in lowering, if a pulling boat. At the same time that the word is passed to "knock off scrubbing clothes," the orders for the morning's work are passed, and from then until breakfast, the officer of the deck is kept pretty busy seeing these orders carried out. The manner of doing this duty will show up the officer's efficiency as well as anything that he does. By the Regulations the officer of the deck is required to see that the crew remove their shoes and stockings while the deck is wet, provided the temperature will permit. When side cleaners are ordered, see for yourself that they get started within a reasonable time. They are under the direct supervision of the mate of the hull and the boatswain. Before they are sent over, send down to the various stewards and have the airports closed that are likely to have water splashed in them. At seven, when the uniform signal is received, notify, beside the captain, the executive officer. Notify all officers of their uniform, notify the captain of marines of the uniform for marines, and tell the first sergeant to have the word passed to that effect; notify the chief master-at-arms of the uniform for the crew and have the word passed during the meal hour by the boatswain's mates of the mess decks; call your relief (this is customary, but its omission is not an excuse for your relief's not relieving on time); after drying down have the coir brushes, swabs, and other wash-deck gear spread out on the deck to dry during breakfast; at 7.45 a numeral flag is hoisted on the flagship to indicate the size of the ensign,

jack, and pennant, to be hoisted at morning colors; at 7.55 sound first call, band call, and call for the sergeant's guard (if used), and have boat awnings spread (if ordered); at eight o'clock report to the commanding officer, "eight o'clock and chronometers[1] wound" (not eight bells), or, in the case of a ship in the presence of a senior, strike the bell with the senior, and report, "made eight o'clock with the flagship," or give name of ship if not a flagship. The following hints are given here as applying more particularly to the morning watch: If practicable, trice up awnings at "turn to" in this watch in order to let the sun get at the deck to bleach it; don't allow the men to hammer the handles on deck when putting on brushes or squeeges, as it disturbs those who are sleeping in; if ashes are to be dumped or the steamers coaled, try to get this work finished before the deck is washed down; in a ship acting singly, when a man-of-war is sighted underway before eight o'clock in the morning, hoist the colors at the peak and keep them flying until the ship anchors, but if she is not anchored before 7.55, haul down the ensign preparatory to regular "colors" at eight o'clock. If in presence of a senior be prepared to follow his motions, which will be as stated above; if the temperature is below freezing, and the morning orders say to wash down, notify the executive officer of the conditions, in which case he may send up word to clamp down with hot water; in shoveling snow off the deck, exercise care that the deck is not gouged with the shovels; if deck is covered with ice, sprinkle the gangways with sand or ashes; when trying to get more force on the deck pump, don't fly into a rage with the man on watch in the engine-room if you can't get it immediately—find out first if the ash-chute flushes aren't turned on; if necessary, whitewash the chain outside the hawsepipes in the morning watch; if moored to dock, have the dock abreast the ship swept and kept free from rubbish as far as possible; if barrels are provided for garbage, they must be kept whitewashed, and the dock in their vicinity kept clean, to do which it may be necessary to send the hose out and wash down, but this is not very good for the hose and should be avoided. If possible, use buckets; any salute the necessity for firing which has arisen since sunset of the previous day, is fired at eight o'clock.

[1] Sometimes the chronometers are reported at noon, in which case, of course, the report is not made at eight.

The Forenoon Watch.

By eight, all men should be in uniform. This regulation is hard to enforce. At "turn to," the running boats and their crews are usually inspected, awnings spread or mended, bright-work cleaned, wash-deck gear stowed away, towel line piped down, boat falls flemished down (if ordered), and the deck titivated. At five minutes before quarters have the officer's call sounded on the lower as well as the upper decks, so that all may hear it. If quarters be delayed or put ahead for any reason, notify the officers and the chief master-at-arms. During quarters and drill the navigator or his assistant usually takes the deck. A little before ten o'clock, find out if the ten o'clock signals are ready. Before the time for "holding mast" have the deck in the vicinity swept, notify the master-at-arms to have the reports at the mast, send for complainants and witnesses, inspect the men and see them in uniform, send for the executive officer's yeoman and the report book, and *when all is ready,* notify the executive officer and ascertain whether he wishes you to inform the captain or to do so himself. At seven bells, have a sample of the crew's dinner brought to the mast. If the food prove unsatisfactory in any respect, notify the commissary officer and refer the matter to the executive officer, first having obtained all the information possible. In order to do this, it may be necessary to send for the commissary steward, the ship's cook, and the mess cook. The same procedure obtains with complaints about food. The justice of a complaint is partially indicated by the character of the man or men making the complaint. A medical officer should be sent for when a question arises as to the quality of the food. A little before noon find out if the noon signals are ready. Noon is reported to the commanding officer in the same manner as eight o'clock; that is, as "twelve o'clock," not as "eight bells," and with the same proviso about chronometers, and being in the presence of a senior.

A caution may be inserted here about meal hours. They should be kept as free from work as possible, although it often happens that something turns up which cannot be put off. By a little forethought it may be possible to avoid breaking into the men's meal hour. If any boat's crews or working parties are away, or have to leave their meals, see that the commissary steward and master-at-arms of the mess deck are notified to have

their meals saved for them. When any absentees do get their meals, allow them, if possible, the same time for eating and smoking as the rest had.

The Afternoon Watch.

If the ship is acting singly, and no special time is allotted on the routine for standing by scrubbed clothes, find out if they are dry long enough beforehand, so that the word can be passed at 12.55 to "stand by scrubbed clothes," and they can be piped down at two bells. If they are not dry, pipe them down at some convenient time in the afternoon when they are, getting them down, if possible, before the liberty party goes ashore, and after the working parties return aboard. If some of the men are absent, send for a master-at-arms to take charge of the clothes that may be left on the line. After piping down have the lines weeded and triced up, or struck below as desired. Hoist jack, as required by the Regulations. If in presence of a senior, follow the motions of the senior ship with regard to piping down clothes and hoisting the jack. If absolutely necessary to pipe down wet clothes, ascertain from the executive officer what disposition to make of them. He may permit the use of the drying-room or a line on the superstructure below the rail.

When the word is passed to stand by clothes, or bedding, or in short, anything that concerns the crew as a whole, always telephone down to the engine-room, dynamo-room, and wherever men are working out of range of the boatswain's mates' voices.

First Dog Watch.

Usually in this watch the liberty party is sent ashore. Ascertain from the executive officer at what time the men are to shift and what the uniform will be, and have the word passed to that effect. In plenty of time beforehand, have the boats alongside, and the liberty party lay aft for muster and inspection. They should be inspected by the officer of the deck, or junior officer of the deck, and may be mustered by the latter or, if the executive officer has no objections, by the executive officer's yeoman.

Allow no one to leave the ship who is not in uniform, neat, and clean. Impress on the men that the ship and the service are judged to a great extent, by their appearance and behavior ashore.

In loading the boat, have due regard to the state of the sea, be particular to have nothing trailing over the side, and make everybody on the thwarts face aft. It would appear to be needless to say that no one should ever stand up in a boat unless, absolutely necessary, but the number of times that this is violated shows that this caution is needed. Before shoving off the boat notify everyone at what time his liberty expires, and what time boats will be sent for liberty men at other times. Men should be encouraged to look on the ship as a home, and to this end they are permitted to return for meals, and to sleep.

If there is to be evening quarters, have the deck cleared up, and if bags or hammocks are to be served out, notify all division officers, including the senior engineer officer and marine officer, except that, in the case of bags, the engineer officer need not be notified, as the engineer's division use black bags, which are not shifted with the others. When bags or hammocks are to be scrubbed, have the boatswain get up the girtlines. Before sunset, have the signal quartermaster, or person detailed, report all signal, running, and anchor lights tested and in good condition, and have whoever is detailed ready to turn the anchor lights on at sunset. At the same time ascertain from the executive officer what boats are to be hoisted and hoist them, having due regard for the supper hour. At first call to colors, beside calling the band and guard (if used), have the boat awnings furled. At sunset, require the coxswains of lifeboats to report them ready for use, and have the lamp-lighter bring up two lanterns, trimmed and lighted, for use in boats after sunset. After colors, unless otherwise ordered, house awnings, slack up signal halliards, take off hatch-hood bags, secure with stern line all boats that are to remain in the water and are not to be used, put covers on exposed guns (that is those whose breech mechanisms are not protected), and searchlights, unless they are to be used.

Second Dog Watch.

"Hammocks" is sounded as per routine. Wait for report from chief boatswain's mate that all are up, when, if customary on the ship, publish the anchor watch, "uncover" and "pipe down." The hammock stowers are required to restow all unclaimed hammocks. The junior officer of the deck should in-

spect and see this done. After this no one is allowed to get a hammock out of the nettings without permission from the officer of the deck. At eight o'clock, if both steamers have steam up, ascertain from the executive officer whether or not one of them is to be secured for the night. In securing a steamer do not let fires be hauled until she is fast to the riding line (sometimes called "guess warp"), otherwise you may have the steamer adrift with no steam up. Require the coxswain to report when the boat has been secured for the night, when you can let him know at what time to be ready in the morning. At the same time notify the senior engineer officer so that he can give orders to have the machinist or coal passer called in the morning. Eight o'clock is reported to the captain. The executive officer receives the reports at this time, and if possible be at the mast so that he may give you any orders he may wish to. The chief master-at-arms reports to the officer of the deck that eight o'clock lights and fires are out (or that an extension is requested), and that the prisoners are secure. The report (or request) about lights and fires is transmitted to the commanding officer.

First and Mid Watches.

At nine o'clock, immediately after "pipe down," the anchor watch is mustered and given instructions for the night—where to sleep, how the watches are assigned, what boat is to be used as a lifeboat, and such instructions as regards the anchor gear as may be deemed necessary. All members of the anchor watch must sleep together and within easy call of the officer of the deck. Their billets are usually assigned by the executive officer. Nine o'clock lights are reported by the master-at-arms to the officer of the deck who, in turn, reports to the commanding officer. If, as occasionally happens, the crew desire an extension, this fact should be reported to the executive officer. With regard to ten o'clock lights, the same procedure is followed as at eight. At one o'clock the second part of the anchor watch is mustered. From ten o'clock until "all hands" the corporal of the guard reports every half hour that lights and prisoners are secure.

Read the morning orders in the mid watch and do whatever you can to facilitate the work of your relief.

THE DAY AT SEA.

Many of the remarks given above apply equally to the ship underway. These will be omitted in what follows.

The Morning Watch.

Before sunrise have the speed-cone boys standing by, and see the halliards clear; have the quartermaster or signalmen standing by the running lights, and also the colors if about to enter port or meeting other men-of-war. Follow the flagship promptly in hoisting cones, etc. At sunrise the deck lookouts lay in and the masthead lookout is sent aloft. Satisfy yourself that the break-down flag is rounded up, the halliards clear, and someone standing by them. Usually the navigator leaves word to be called about this time or a little before, if the weather is clear. At sea the routine differs somewhat from the port routine. After mustering the watch and lifeboat's crew, until 4.30 is allowed for coffee. At 4.30 the watch turns to, but it is often too dark to accomplish much. However, the hose can be led out, the wash-deck gear broken out, and things gotten ready for daylight. Idlers are called at five o'clock, and have a half hour for coffee. During the morning watch at sea, in squadron, the junior officer of the deck and the boatswain have most to do with the actual carrying out of the morning orders, as the officer of the deck is busy with his other duties. This, however, does not relieve him of any responsibility with regard to their being carried out properly.

The Routine for the Rest of the Day.

The routine for the rest of the day does not differ much from that at anchor. Sometimes the crew go to meals by watches, and sometimes both watches eat together. At eleven, or thereabout, the clocks are reset. The navigator reports to the officer of the deck how much the clocks are to be set ahead or back, and the latter, after obtaining permission from the commanding officer, sends the chief quartermaster to reset them. The executive officer, the senior engineer officer, and the chief master-at-arms are notified of the change. The navigator reports to the officer of the deck when it is meridian, together with the noon latitude, both of which are reported by the latter to the com-

manding officer. The same caution about being ready as far as possible with routine signals applies as has already been given. As a matter of interest, if convenient, have the latitude and longitude signals from other ships noted and send them to the commanding officer. Before sunset have men standing by the running lights, speed lights, speed cones, and colors, in order to follow the motions of the flagship promptly, also get the oil stand-by lights trimmed, lighted, and stowed conveniently near the bridge, taking care to have them well screened. At sunset muster *all* lifeboat crews, and have the coxswain report the boats inspected and ready for lowering. The ship's position is often signaled at eight o'clock. Just before eight the boatswain, after reporting the wheel and lookouts relieved, is told to "set the watch with the bell," after which the watch and lifeboat crew are called to muster, and the coxswain, beside reporting the crew present, reports having inspected both lifeboats, and that they were ready for lowering. Call the next watch and relieve the wheel and lookouts as per routine. The same reports as to the watch and lifeboat crew and the condition of boats are made at midnight as at eight o'clock. A carpenter's mate reports at least twice during each watch as to the water in the bilges, and that all ports are closed that should be. A gunner's mate reports at least twice during each watch the condition of the battery. The Regulations require that the junior officer of the deck be sent to make an inspection below decks every two hours, or oftener if necessary, when his services can best be spared. There are no lights reported at nine o'clock at sea, as they are extinguished at eight. The officer of the deck should not allow himself to be relieved until the wheel and lookouts have been relieved.

VARIOUS OTHER DUTIES.

Preparing Ship for Sea.

The ship's station bill in all probability includes the preparations for sea. In many cases some of the preparations laid down may be dispensed with, as, in short trips, the accommodation ladders and quarter booms may be triced up instead of being rigged in, but for example, we shall assume that the officer of the deck has received orders to "prepare ship for sea, and be ready to get underway at . . . o'clock," Notify all officers that

the ship will get underway at . . . o'clock. Having ascertained from the executive officer what boats are to be left down until the last, proceed to hoist the others and secure them for sea; reeve anchor gear (unmoor if moored, but the executive officer usually takes the deck for this); rig in and unrig lower and quarter booms; rig in and secure accommodation ladders; secure cranes and all loose articles about the decks; have lifeboats rigged and provisioned for sea (sometimes all boats are provisioned and watered when getting underway); send side cleaners around to take off scupper lips; secure turrets and broadside battery, putting on port shutters; put on gun and muzzle covers and searchlight covers; have signals ready; test steering engine; test annunciator and all communications from the bridge; test whistle and siren with the flagship; after obtaining permission from the commanding officer, and satisfying yourself that all is clear astern, send a reliable man on the bridge to work the indicators, and test the main engines when they are ready in the engine-room; send chain tierers below; start the deck pump for washing the chain; have helmsman, leadsmen, and cone boys at their stations; station a hand at the breakdown flag, one at the jack, and two aft to shift the colors; lower the clothes on tarpaulins if ordered; report to commanding officer and executive officer when ready. All hands are usually called five minutes before getting underway, when the executive officer takes the deck.

Briefly, the duties of the other officers are as follows, and these officers are responsible to the officer of the deck that the preparations are made. Division officers should hold the petty officers responsible.

Division Officers. Secure turrets by clamping down watershed, putting in securing bolts and turnbuckles, putting in sea tompions, putting on muzzle bags, and rigging port bucklers. Secure broadside battery by putting in sea tompions, greasing muzzles and all unprotected steel work, putting on muzzle bags, and shipping port shutters. Every officer sees everything secured in his part of the ship.

Signal Officer. Place signal flags on boards ready for hooking on; bend on any signal that will be used; send up breakdown flag; station cone boys, man at breakdown flag, man at affirmative, man at jack, man at reserve speed pennant, and two aft for shifting colors; put on bridge screens if ordered. The signal

officer should require his signal quartermaster to make these preparations, and when he has satisfied himself that they have been done, should report to the officer of the deck.

Assistant to the Navigator. Breaks out such charts as the navigator designates and looks up corrections for the same; provides parallel rulers, dividers, pencils, and weights; provides stadimeter.

Boatswain. Breaks out anchor gear, reeves cat fall, etc., and reports to officer of the deck when ready to heave short.

Gunner. Assists in securing battery, and secures magazines; tests lifebuoys and reports to officer of the deck.

Carpenter. Sees all airports closed, except those authorized to remain open, and takes the ship's draft forward and aft, reporting to officer of the deck, who reports the ship's draft to the commanding officer and the navigator and enters it in the log. The carpenter also stations a man at the anchor engine, tests same and reports to the officer of the deck that it is ready for use; sends some of his gang to help rig in the accommodation ladders, and sometimes assists in securing the gun ports.

Duties of others are as follows:

The master-at-arms and the corporal of the guard search the ship for visitors and report to the officer of the deck when ship is cleared.

The chief quartermaster rigs the sounding machine; tests the annunciators and communications from the bridge; connects up, and after obtaining permission from the officer of the deck, tests steering engine, reporting to the officer of the deck when his duties are completed.

The coxswains of boats secure their boats with the assistance of the rest of the crew, and provision them if required, reporting to the officer of the deck when finished.

The officer of the first division is in charge on the forecastle when getting underway, and if the anchor engine is on the lower deck the officer of the powder division is in charge there.

After leaving port do not put sea lashings on the anchors or have the leadsmen lay in without first obtaining permission from the commanding officer. Notify the executive officer when the sea lashings are put on.

Coming on Soundings.

Before coming on soundings have leadsmen detailed and lead-lines placed in readiness. When in pilot waters go ahead with soundings and ascertain from the commanding officer whether the sea lashings of the anchors are to be taken off or not, notifying the executive officer if they are taken off.

Coming into Port.

Get general orders from the executive officer regarding the preparations to be made for port, which may or may not include all of the following:

Take covers and gripes off boats and strike provisions below; coal and water the steamers unless it is deemed the added weight will be too great for the cranes or davits to bear with safety; light fires in steamers as ordered; if the gig is to be used have the crew prepare the boat and get in clean uniform; rig lower booms, quarter booms, and accommodation ladders; remove turret and gun-port shutters, and take off muzzle bags; remove sea tompions and put in port tompions; have junior officer of the deck, mate of the hull, or boatswain inspect the side to see if there are any lines trailing overboard, if the guns are square, etc.; haul taut signal halliards and mend awnings if necessary; remove gun and searchlight covers; take lashings off cranes, chests, etc.; hoist ashes just before entering the harbor; when reasonably certain as to the time of anchoring, get permission from the captain to notify the senior engineer officer that the ship will anchor in about . . . minutes; if ordered, lower the clothes on a tarpaulin.

Just before anchoring all hands are usually called. Stand by anchor, see everybody clear of chains; have man or men ready to stream buoy; man forward lower boom guys and topping lifts and tend after guys; be ready to lower accommodation ladders and quarter booms; have men stationed to shift colors, tend jack, and tend position pennant. The officer of the forecastle has immediate charge of everything that takes place on the forecastle, the officer in charge on the quarter deck has immediate charge of whatever takes place aft, and the signal officer has charge of whatever has to do with signals.

It often happens that the time of anchoring interferes with a meal hour. If it seems likely that this will be the case send word to the executive officer, and if he orders a change in the meal hour send word to the commissary officer and the chief master-at-arms that such order has been given. If a boat is to be sent away on anchoring and it is likely that the crew will be away during the meal hour and some time afterward, have their meal prepared and eaten beforehand, if possible, first obtaining permission from the executive officer. If mail is to be sent ashore, notify the officers by messenger and the crew by having the word passed, that the mail will close in . . . minutes. After anchoring you will probably receive from the executive officer orders as to side cleaners, etc. If pratique is to be obtained, no boat is allowed alongside before that of the health officer, and under no circumstances are visitors allowed to come aboard without permission from the executive officer.

Writing the Log.

In writing the log, be concise but enter all that is required, following carefully the directions in the front of the log book as well as the Regulations. Distinguish between captain and commanding officer. There is only one captain and he may not be aboard, but the ship is never without a commanding officer.

GENERAL REMARKS.

Underway.

Always, before getting underway, refresh your mind on the rules of the road, and the "Tactical Signal Book." When coasting, and if the opportunity presents itself. take frequent bearings to satisfy yourself as to the ship's position. If at all likely to be used, keep leadlines near the sounding platforms, and see that they are kept clear. Have leadsmen detailed beforehand. During foggy weather, both at night and in the daytime, have lookouts aloft and close to the water, as fog often lies in layers, and it is claimed that fog signals can be heard better aloft under certain conditions. In rough weather, if it is necessary to batten down forward, do so in plenty of time, as it is dangerous work unshipping ventilators and dogging down hatches with water coming aboard forward. When helmsmen relieve one another, make the one going off watch report the course he has turned over to his relief.

At Anchor.

Before foggy weather sets in, get bearing of landing and of other ships for the information of coxswains of boats that may have to be sent. In heavy weather, hoist boats as ordered; get bearings on shore (preferably ranges); put over the drift lead and detail someone to watch it; put steadying lines on boats at davits; trice up accommodation ladders; have someone make an inspection of the anchor gear, to see that everything is ready for letting go another anchor if necessary, and that the stoppers are holding properly. If boats are coming alongside it may be possible to afford a lee by putting the helm[1] one way or another. Boats usually lie better astern than at the boom unless the ship is riding to a windward tide, but difficulty is experienced in getting the men into and out of the boat when it is lying astern, as the boat is likely to ram the ship and stave a hole in herself. In case of rain, house awnings; slack up the gear; cover the hatches; pipe down bedding or clothes, except that in the presence of a senior, permission must be obtained if no signal has been made; remove plugs from boats. Always keep a bright lookout for approaching rain squalls, especially when bedding is being aired. Remember that by the failure to do this one man may cause eight hundred to pass an uncomfortable night due to damp bedding, to say nothing of the danger to health thereby engendered. It is the duty of the quartermaster to report the approach of rain squalls, but as in so many other cases the excuse, "the quartermaster did not report it to me," reflects no credit on the one giving it.

When the admiral's barge is called away, ascertain from some member of the personal staff whether the admiral is leaving officially or not, and what honors he wishes. Whenever the admiral leaves the ship, in addition to notifying the commanding officer, notify the members of the personal staff, and the executive officer. When the captain is going to leave the ship ascertain whether he is leaving officially or not, and what honors he wishes. In this case it is necessary to notify the executive officer only. When the barge or gig returns to the ship, find out from the coxswain what orders he has received. In the case of the admiral having given the orders, notify the commanding officer and the members of the personal staff. In case the orders have come from the cap-

tain, notify the executive officer. In both cases turn over such orders to your relief if not already carried out.

Notify the executive officer of the following: Any orders from the captain affecting the ship; any unforeseen trips of the ship's boats or any mishaps to them; the arrival and departure of officers senior to him, of boards, and of visiting parties from other ships; and keep him informed of the condition of the weather when it is likely to affect any orders he may have given, such as orders to paint the side, etc. When the executive officer or the acting executive leaves the ship, notify the officer upon whom the duties of executive devolve. Notify all heads of departments of the arrival of boards of survey on articles in their charge.

Refer the following to the executive officer: Whether and for how long visitors are to be allowed aboard; whether bumboatmen and tradespeople shall be allowed aboard, and in case they are allowed aboard, send for the chief master-at-arms to inspect articles and oversee the sale. Have food-stuffs in bumboat inspected by medical officer.

When coming on watch for the first time, ascertain the custom with regard to the boat gong; but under ordinary circumstances do not sound it before eight o'clock in the morning.

Don't allow any boats to remain alongside longer than necessary, and don't allow steamers to fire up while they are alongside. In sending boats away at night inspect personally to see that they have their proper lights burning. Keep boatswain's mate, messengers, bugler and side-boys (if needed) within easy call. Be particularly careful to have the quartermaster report every occurrence of interest, and don't overlook the slightest negligence in this respect. He is on the bridge to act as another pair of eyes for the officer of the deck, and upon his vigilance much may depend. Don't accept the excuse, "I didn't see it"; that's what he's on the bridge for—to see, and report. Similarly, in the case of the boatswain's mate, don't accept from him the excuse, "I passed the word"; it's his business, not only to pass the word, but to see the order obeyed, under ordinary circumstances. When sending boats away for special purposes, inform the coxswains and see that they make the proper preparations, thus: If sending for stores, tarpaulins should be provided; if sending for money, a buoy and line should be provided, etc.

Before firing a salute, have the awnings spread, if housed or triced up, and the clothes-lines lowered on deck. Return all salutes to the quarter-deck, whether from people coming from over the side or up a hatch. In hoisting boats by the winch or crane, send down to the dynamo-room in plenty of time beforehand to get the power on and for men to tend them. In using searchlights exercise the utmost care not to flash the light on other vessels. When airing bedding, unless ordered to the contrary, keep the starboard side of the quarter-deck clear of hammocks, and in lashing them keep the gangways clear. The junior officer of the deck should see that the petty officers in charge of parts of the ship carry out these orders.

The officer of the deck inspects fresh provisions purchased for ship's use, as to quantity, and he should send for a medical officer who inspects them as to quality. The latter also must be notified when fruit and other articles of food and drink are brought alongside for sale, as he is required by the Regulations to inspect them frequently.

Don't allow boxes, or barrels, or other articles that float, to be thrown overboard. They are to be broken up on deck, and sent to the fire-room to be burned. In hot weather, when the awnings are not spread, sprinkle the deck occasionally. If the smoking lamp is asked for by a petty officer, and you, as officer of the deck, have no objection to granting the request, refer the matter to the executive officer, or follow his previously expressed ideas on the subject. Never allow any signals to be sent unless by permission of the officer of the deck. Never allow anyone but an officer or your own representative to communicate through the quarter-deck or bridge telephones or speaking tubes without permission.

The orderly usually reports times as set down in the routine, but his failure to do so doesn't relieve the officer of the deck of any responsibility in the matter. Use the orderly to convey all messages to the commanding officer, except when the latter is on deck (or on the bridge, if at sea) in which case make reports in person. Always cause the messenger to report having delivered a message when he has done so.

When investigating complaints, have both parties at the mast. Cause the complainant to tell his story in the presence of the other, and when he has finished let the one accused tell his story in the

presence of the accuser. Don't let more than one man talk at once, and always investigate thoroughly before putting a report on the report book. If the case is of sufficient gravity, such as refusing duty, striking a superior officer, or disorderly conduct aboard ship, etc., notify the executive officer at once. In your intercourse with the crew, avoid nagging, and don't fill the report book with trivial reports.

In conclusion, it is necessary to bear in mind that a watch officer must, if he wishes to become efficient in that branch of his profession, possess forethought—must be continually thinking, "what is going to happen that I can provide for now?" and above all must one obey orders without question: When given an order, don't hesitate, don't ask how to do it, don't suggest that now is not a convenient time; remember that whoever gave the order doubtless has reasons that you know nothing about; answer, "aye, aye, sir," and obey—that's all. Likewise, exact the same from subordinates: When you give an order, *see* that it is carried out, and don't have to give such feeble excuses later on, when it is discovered that the painter failed to mix the shellac, as, "I gave the order," or, "I thought he had it ready." Results are looked for in the navy.

OTHER DETAILS.

The Assistant to the Executive Officer.

The assistant to the executive officer has various duties, differing on different ships. They often include a supervision over the issue of stores; the detailing of working parties, and such details as messmen and strikers, compartment cleaners, strikers for the gunner's gang and carpenter's gang, etc.

The Assistant to the Navigator.

The duties of the assistant to the navigator usually include the following: At sea, regular day's work, recording bearings for the navigator if coasting, making out azimuth tables before swinging ship; in port, making out sunset and sunrise tables, comparing chronometers and entering data, filling out compass report blanks and chronometer rate curves, and almost always the correction of charts and filing the "Notices to Mariners," and filling out the meteorological report.

Mates of the Decks.

The duties of mates of the deck have principally to do with the cleanliness and order of the decks to which they are assigned. They are called at "all hands" by the officer of the deck, and report to him for orders. They are responsible for the carrying out of the morning orders, each on his own deck, and have as assistants usually a master-at-arms, and sometimes a boatswain's mate. They should allow no loafing on their decks during the morning watch; and should see that the soap and cleaning gear allowance is properly used and is not diverted to private purposes; should see wash-deck brushes, handles, swabs, buckets, etc., plainly marked and stowed in the proper place when not in use or being aired; should keep the cleaning bill up to date, and notify the executive officer (or sometimes the division officers) when it is necessary to replace absentees; should superintend when the deck is being scrubbed, painted, or shellaced; and should report their decks to the executive officer as being ready for inspection every morning at nine o'clock.

NOTE.—The duties of a mate of the deck on a midshipman's practice ship are more comprehensive, and being of a special nature are not enumerated here.

APPENDIX.

§ I. SAILING SHIPS.

Although sails and spars have practically disappeared from the navy and from the experience of the average seafaring man even in the merchant service, they are far from having disappeared from the ocean; and some familiarity with them may still be expected on the part of every seaman who aspires to be even tolerably well informed in his profession.

Plates **149**, **150**, and **155** show the various rigs which are commonly seen in deep-sea vessels.

A **ship**, often referred to as "a full-rigged ship," has three masts; the fore, main, and mizzen, all of them square-rigged.

A ship may have more than three masts. Four-masted ships are common, and five-masters are occasionally seen. In a four-master the after-mast is called the jigger-mast. In a five-master, the masts are usually called "fore," "main," "middle," "mizzen," and "jigger."

A **Barque** has three masts, the fore and main square-rigged, the mizzen, fore-and-aft rigged.

A barque, like a ship, may have more than three masts, the names being the same as in the case of a ship. She is still a barque if all the masts except the after one are square-rigged.

A **Barkentine** has three or more masts, of which the two after ones, main, and mizzen, or mizzen and jigger, are fore-and-aft rigged. A five-master, with the three after-masts fore-and-aft rigged is still a barkentine.

A **Brig** has two masts, both full square-rigged. A brigantine is a brig without a square mainsail; that is to say, she carries all the square sails of a brig on both fore and main masts, except the mainsail.

A **Hermaphrodite Brig** has two masts, the foremast full square-rigged, the mainmast full fore-and-aft rigged. A hermaphrodite brig is often incorrectly called a brigantine.

A **Topsail Schooner** has a fore-and-aft foresail, with a square

Plate No. 149.

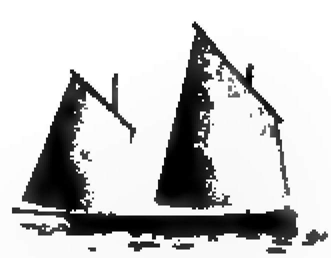
HERMAPHRODITE BRIG.

TOPSAIL SCHOONER.

SCHOONER
may have as many as five
masts

KETCH.
YAWL, same as KETCH but
with a smaller mizzen
abaft the tiller.

CUTTER



LUGGER

SAILING CRAFT.

FULL RIGGED SHIP.

BARQUENTINE.

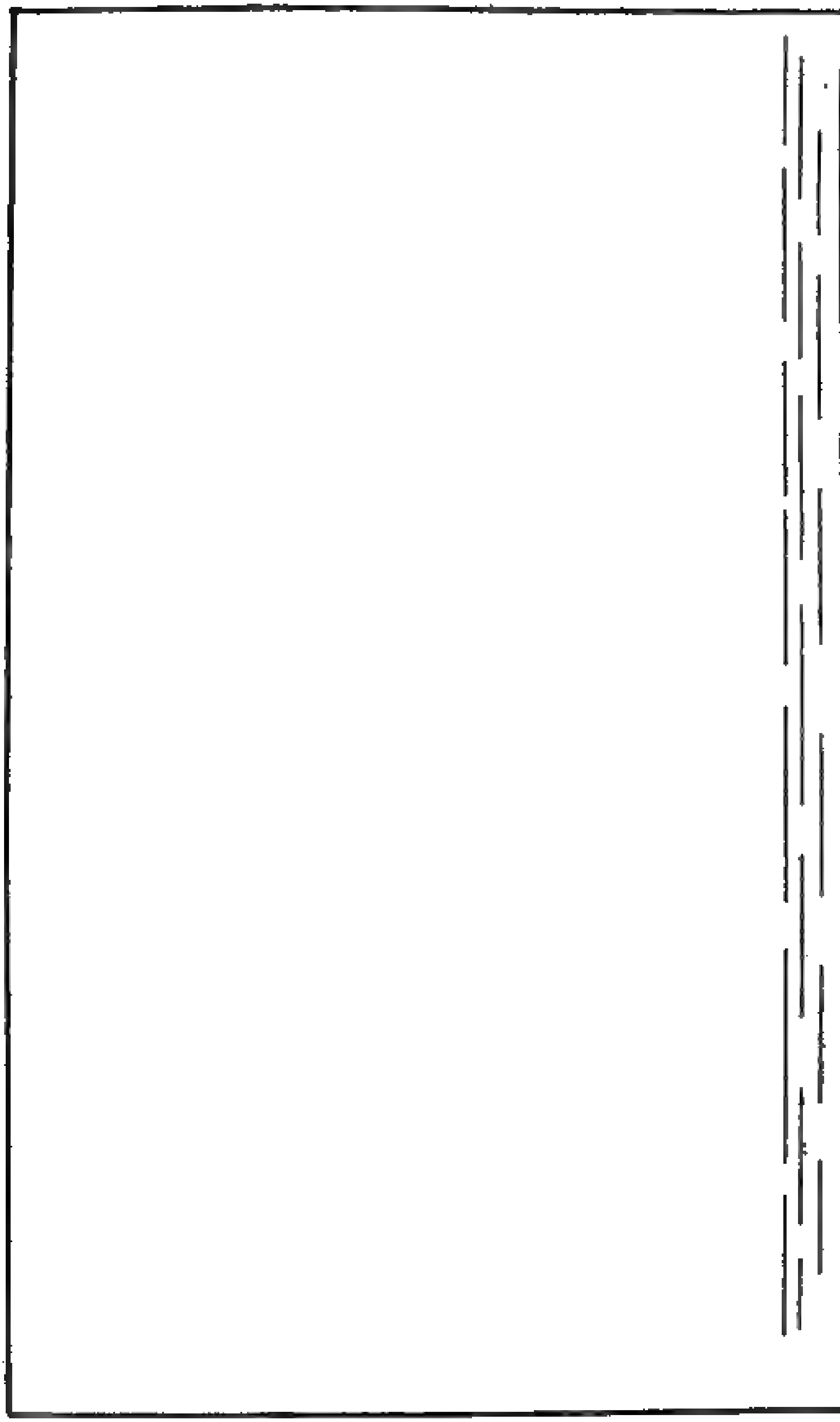
BRIG.

BRIGANTINE same as BRIG., but without a square mainsail.

BARQUE.

SAILING CRAFT.

Plate No. 150.



FOUR-MASTED SHIP UNDER SAIL.

1 Foresail	12 Upper jigger topsail	29 Spanker
2 Mainsail	13 Fore topgallant sail	30 Buntlines
3 Crossjack	14 Main topgallant sail	31 Leechlines
4 Jigger	15 Mizzen topgallant sail	32 Reeftackles
5 Lower fore topsail	16 Jigger topgallant sail	33 Braces
6 Lower main topsail	17, 18, 19, 20, Royals	34 Foresheet
7 Lower mizzen topsail	21, 22, 23, 24, Skysails	35 Fore topmast staysail sheet
8 Lower jigger topsail	25 Flying-jib	36 Jib-sheet
9 Upper fore topsail	26 Outer-jib	37 Outer jib-sheet
10 Upper main topsail	27 Jib	38 Flying jib-sheet
11 Upper mizzen topsail	28 Fore topmast staysail	

KEY TO PLATE 150

1 Foremast
2 Mainmast
3 Mizzenmast
4 Topmasts; fore, main and mizzen.
5 Topgallant masts; fore, main and mizzen.
6 Royal and skysail masts; fore, main and mizzen.
7 Fore yard
8 Main yard
9 Crossjack yard
10 Lower topsail yards; fore, main and mizzen.
11 Upper topsail yards; fore, main and mizzen.
12 Lower topgallant yards; fore, main and mizzen.
13 Upper topgallant yards; fore, main and mizzen.
14 Royal yards; fore, main and mizzen.
15 Skysail yards; fore, main and mizzen.
16 Spanker gaff
17 Trysail gaff, fore and main
18 Lower shrouds
19 Topmast shrouds
20 Back stays
21 Fore skysail stay
22 Fore royal stay
23 Flying-jib stay
24 Fore topgallant stay
25 Jib stay
26 Fore topmast stays
27 Fore stays
28 Main skysail stay
29 Main topgallant stay
30 Main topmast stay
31 Mizzen skysail stay
32 Fore and main lifts
33 Topsail lifts
34 Topgallant lifts
35 Spanker boom
36 Bowsprit
37 Jib-boom
38 Flying jib-boom
39 Martingale or dolphin striker
40 Braces (named from yard to which they belong)
41 Bobstays
42 Martingale guys

KEY TO PLATE 151

Plate No. 151.

STANDING AND RUNNING RIGGING.

fore-topsail, and in some cases a fore-topgallant sail. The main-mast is full fore-and-aft rigged. A topsail schooner is often incorrectly called a hermaphrodite brig.

A **Schooner** has two, three, or more masts, all fore-and-aft rigged. The designations of the masts where there are more than two are the same as in the case of a ship or a barque.

There are many variations in the single-masted rig shown in the **Cutter** of Plate **149**. The " sloop " differs from the cutter so far as rig is concerned in having a short fixed bowsprit instead of a long moveable one, and in carrying only one head sail. The most important distinction, however, between the sloop and the cutter, as at present recognized by yachtsmen, has to do with the model of the hull rather than with the rig.

The **Ketch** and the **Yawl** are modifications of the single-master rather than of the schooner, since they have grown out of the desire to make the total sail area more manageable by dividing it. For racing, the " single-sticker " holds its own because, as is well known, a given amount of canvas has far greater *driving* power in one sail than in two. An incidental advantage of the yawl or ketch rig is that the craft can be handled under very small sail—jib and jigger—which is a great convenience in working around a harbor, and may be of vital consequence in bad weather when the mainsail must be lowered, perhaps only for reefing; a situation in which the boat under a jib alone would be altogether unmanageable, and reefing a difficult and dangerous operation.

The same considerations of manageability with a small crew which have led to the development of the yawl and ketch from the single-master, have led to the division of the mainsail of large schooners, resulting in the production of schooners of three, four, and more masts.

As regards the merits of the fore-and-aft rig as compared with the square-rig, it may be said that the fore-and-after has marked advantages on the wind, and the square-rigger advantages quite as marked in running free, especially in bad weather. A square-rigger before the wind is as manageable and comfortable as on any other point of sailing, but the fore-and-after, if there is any sea running, is in a situation which is at the best a difficult and trying one, and at the worst is very dangerous.

Details of Rigging—Square-Riggers.

Masts. Lower masts in modern ships are usually built up of steel plates stiffened in various ways by steel shapes.

Built-up masts of wood are no longer used, although lower masts made of single pine sticks are not uncommon in sailing ships of moderate size.

Topmasts and topgallant-masts are still made of wood, usually of pine.

The mast rests on a step, placed as low as possible; usually on the keelson. At the lower end is a *tenon* fitting into a *mortise* at the step. Where the mast passes through the successive decks, timbers are built in from beam to beam, forming *partners;* the space between these and the mast being filled by tightly fitting wedges.

The masthead is smaller than the body of the mast, and at the shoulder, called the *hounds,* where the reduction in size is made, heavy knees or *bibbs,* are bolted on, widening the shoulder and forming a secure support for the *trestle-trees;* stout fore-and-aft pieces which, in their turn, support the *cross-trees,* the *top,* the *topmast,* and the eyes of the lower rigging. The cross-trees are athwartship pieces crossing the trestle-trees forward and abaft the masthead, and forming the principal part of the framing of the top. They are jogged down into the trestle-trees, and with the latter form a skeleton to which the comparatively light planking of the top is secured.

The lower masthead terminates in a square tenon, to which the *cap* is fitted. This may be of wood, iron-bound, or built up of steel.

The topmast passes through a round hole in the forward part of the cap, which thus binds the two masts together. In the heel of the mast is a thwartship hole, square in section, through which is placed an iron *fid,* with its ends projecting and resting on the trestle-trees on either side. Two sheaves placed diagonally in the heel of the topmast furnish a lead for the top pendants, by which the mast is sent up and down. The over-lapping parts of the lower masts and topmasts are the *doublings.*

The topmast head is fitted in practically the same way as the lower masthead, and the heel of the topgallant-mast "doubles" upon it similarly. Cross-trees are used here as spreaders for the topgallant rigging, but without a top.

Topgallant and royal masts are in one, but the diameter is reduced at the topgallant masthead forming *hounds,* upon which rests the topgallant *funnel;*—a composition cylinder, with two thwartship arms forming the "*Jack.*" At the royal masthead is a similar shoulder, with an iron band for the rigging, and above this is the *pole* terminating in a tenon to which the *truck* is fitted. The truck usually carries the point of a lightning conductor, the lower end of which makes contact with the hull, or, in the case of a wooden ship, with the copper well below the water-line.

Trysail masts are fitted up and down abaft the lower masts, being stepped on deck and secured at the head by bands connecting by a key to corresponding bands on the lower mast.

Modern men-of-war rarely carry sail, and such masts as they have are usually for military purposes only;—in some cases for carrying light guns in elevated positions, in other cases merely for signalling.

Yards. A full-rigged ship carries a lower, topsail, topgallant, royal, and sometimes a sky-sail, yard, on each mast. The topsail and topgallant yards are often double (Plates **150, 151**).

Standing Rigging. The masts of a ship are supported from the sides by *shrouds,* from forward by *stays* and from aft by *backstays.* The *backstays* contribute also to the sidewise support since they are necessarily led to the sides of the ship. The *stays,* in addition to supporting the masts, serve to carry certain fore-and-aft sails known as *staysails.* For convenience in hooking tackles at the mastheads for various purposes, heavy *pendants* are provided, fitted with thimbles and links and hanging well clear of the other rigging. Small lines, called "ratlines," stretched from shroud to shroud, furnish the means of going aloft.

The head-booms are supported from beneath, against the pull of the stays and the lifting tendency of the head sails, by *bobstays, martingales,* etc., leading to the cut-water; and from the sides by *bowsprit shrouds, jib-* and *flying jib-guys,* leading to the bow.

The above constitute the "Standing Rigging" of a ship.

Standing Rigging is usually fitted of galvanized steel-wire rope, plain-laid, of six strands, and is protected from the weather,

FORE MAST AND HEAD-BOOMS OF A MODERN SAILING SHIP.

chafe and wear, by a thorough covering of worming, parcelling and serving (Plate 22).

Sails. Sails are made of canvas, which may be of flax, hemp or cotton. The sails of ships are always of flax, those of boats and small yachts usually of cotton. Cotton canvas is used also on ship-board for a variety of purposes, such as awnings, windsails, hammocks, tarpaulins, etc.

Canvas is manufactured in long strips or *cloths,* varying in width from 16 to 24 inches for flax, and from 20 to 42 inches for cotton, and in lengths of from 40 to 80 yards. The cloths are made up in rolls called *bolts.*

Variations in weight, strength and fineness are indicated by numbers running from 1 to 10; number 1 being the heaviest, strongest and coarsest, and number 10 the lightest and finest.

In the United States Navy, canvas is used as follows:

For the sails of ships, flax canvas, 24 inches wide, issued in bolts of 80 yards. For awnings, screens, etc., cotton canvas, 22 inches wide, in bolts of 90 yards. For hammocks and bags, cotton canvas, 42 inches wide, in bolts of 90 yards. For boats' sails, cotton canvas of the variety known as "raven's duck," 28½ inches wide, in bolts of 65 yards.

Good canvas is made of long, strong, clean threads, evenly spun and well twisted and without any mixture of tow. In the heavier grades (Nos. 1 to 3), the threads are double, and in all grades the cloths should be closely and uniformly woven, and with a firm, even selvage. To test a sample of canvas, after examining carefully the character of the texture as to the smoothness and closeness of the weaving, it is well to bore through with a fid, when the threads will break easily if of inferior quality, and resist, with a disposition to stretch before yielding altogether, if of good strong staple. A few threads may be drawn and examined as to length, smoothness and freedom from tow; and finally, if two samples are to be compared, similar strips from the two may be knotted together and tested by hanging weights from them to determine which is the stronger.

An 80-yard bolt of No. 1 flax canvas, 20 inches wide, should weigh about 75 lbs. and the successive numbers from this to No. 10 should diminish by about 5 lbs. each, a bolt of No. 2 weighing 70 lbs., one of No. 3, 65 lbs., and so on.

The following numbers are commonly used for the sails of a full-powered sailing ship, the lighter grades specified in each

case forming a fair-weather suit of sails, while the heavier ones are bent in anticipation of a stormy passage:

Courses,	Nos. 1 to 3.
Topsails,	" 2 to 3.
Topgallant sails,	" 4 to 5.
Royals,	" 5 to 6.
Topmast staysails,	" 3 to 4.
Jibs,	" 4 to 5.
Other staysails,	" 4 to 5.
Spankers, trysails, etc.,	" 4 to 5.
All storm sails,	No. 1.

The square sails of a ship (Plates **149** and **150**) are the *courses* (foresail and mainsail), the *topsails, topgallant sails* and *royals.* A *skysail* is sometimes set above the royals. Topsails and topgallant sails may be single or double.

The fore-and-aft sails are the fore-and-main *trysails,* the *spanker* (which is in reality a mizzen trysail), the *staysails,* taking their names from the stays on which they are set, and the *jibs,* which are also staysails, although not so-called. The trysails are called also *spencers,* and the spanker is often called the *driver.*

The upper edge of a square sail is called the *head,* the lower edge, the *foot,* the sides, *leeches,* the upper corners the *head cringles,* the lower corners, the *clews.*

In the case of a four-sided fore-and-aft sail like a trysail or spanker (Plate **154**) the after edge is the *after leech,* the forward edge the *luff,* the upper edge the *head,* the lower edge the *foot,* the upper after corner the *peak,* the upper forward corner the *nock,* the lower forward corner the *tack,* the lower after corner the *clew.*

In a triangular sail (Plate **154**), the edge next the stay is the *luff,* the after edge the *leech,* the lower edge the *foot,* the lower forward corner the *tack,* the lower after corner the *clew,* and the upper corner the *head.*

The details of sails of various kinds are fully shown in Plates **149**, **153**, and **154**.

The cutting and making of sails constitute an art in themselves, which it would be beyond the province of this book to attempt to teach. The canvas must be cut with care, not only to economize material in adapting the narrow cloths to the irregular shapes required, but to reduce stretching to a minimum and to distribute

FORE MAST AND HEAD-BOOMS OF A MODERN SAILING SHIP, SAILS SET.

such stretch as cannot be prevented, in a way to avoid distorting the sail and allowing it to bag. Canvas stretches very little along the line of the threads of either warp or filling, but may give considerably under a diagonal pull. Owing to the way in which sails are set (being hauled out by their corners), the greater part of the strain to which they are subjected is diagonal, and one of the most difficult points in sail making is to arrange the material in such a way that the cloths may take this strain directly along the threads. When this has been done as far as possible, allowance must be made for the stretch which still remains, and also for the difference in stretching between the canvas and the roping.

The cloths are sewed together with overlapping (double) seams having from 110 to 130 stitches to the yard. The twine used should be of good flax or cotton, spun with from three to eight threads and waxed with pure beeswax.

Sails are reinforced at points which are subject to especial strain or chafe.

The edges of the sail all around are turned over, forming a hem or *tabling* several inches wide. The linings and other strengthening pieces are then sewed on, and lastly the *bolt-rope.* This is of hemp and should be of the best quality, rather loosely laid up to make it soft and pliable, and tarred with the best Stockholm tar. As there is more stretch to the rope than to the canvas, care must be taken to leave a little slack canvas along the edges, as otherwise the canvas, instead of the roping, would take the strain when the sail is set. A common rule is to allow one inch of slack canvas for every foot along the leeches of topsails and canvas, and one inch for every yard along the foot.

The roping of square sails is always on the after side of the sails, that of fore-and-aft sails usually on the port side.

Double Topsails and Topgallant Sails. Modern sailing ships almost without exception have double topsail yards and in many cases double topgallant yards as well. This rig was first proposed by an American shipmaster named Howe, and its many advantages were promptly recognized (Plates **149** and **153**).

In this rig, the lower topsail yard is fixed, while the upper yard hoists and lowers, the sail having half the depth of a single topsail. The lower (topsail) yard is trussed to the main cap, and the upper yard, when lowered, lies close above it. Thus by lowering the upper topsail, sail is reduced in a moment to the area

of an old-fashioned topsail when close-reefed, the upper topsail, when lowered, hanging forward of the lower topsail, where it is to a great extent becalmed.

Downhaul tackles are fitted from the yard-arms of the upper to those of the lower (topsail) yards to haul the yards down. This takes the place of "clewing-down" with a single topsail. The downhauls also support the lower topsail yard-arms, for which, usually, no lifts are fitted.

The lower topsail is fitted with sheets and clew-lines like an old-fashioned topsail, but as the leech is short, the clew-line blocks are placed well out on the yard. As a rule, the clews of the upper topsail shackle permanently to the lower topsail yard-arms.

Running Gear. The ropes, purchases, etc., by which the yards and sails are controlled constitute the Running Gear of the ship. Most of this gear is shown so clearly on the plates herewith, that a detailed description of their lead is unnecessary.

Halliards. Yards are hoisted by purchases consisting usually of a pendant, called a tye, and a purchase called the halliards.

The halliards of a staysail are bent to the head of the sail, lead up along the stay to a block at the masthead and thence on deck. For heavy sails, the halliards are double, and reeve through the blocks at the head of the sail, the standing part being made fast aloft and the hauling part leading as before.

The gaffs of trysails are supported by spans from the lower mast to the throat and peak, and when necessary may be hoisted and lowered by *throat* and *peak* halliards (Plate **154**).

Lifts. Yards are supported at the yard-arms by lifts, leading through blocks or fair-leaders at the masthead and thence to the top or the deck.

Braces. Yards are controlled as to their horizontal movement by *braces* leading from the yard-arms aft or forward. They are always led aft if circumstances permit this without requiring too much of a downward lead. In three-masted ships, the braces of yards on the fore-and-main are led aft, those of yards on the mizzen, forward.

Sheets. The clews of square sails are hauled out to the yards below them by sheets, reeving through sheaves in the yard-arms, thence through quarter-blocks under the yard and so to the deck.

Staysail and trysail sheets consist of pendants and whips, and are usually double, each sail having its port and starboard sheet.

Single Topsail.

Spanker.

DETAILS OF SAILS.

In the case of a sail hauling out to a boom, the purchase for controlling the boom is the "sheet" and the sail is hauled out by an "outhaul."

Tacks. To control the clews of the *courses*, not only sheets, but *tacks*, are needed, the tack hauling the weather clew down and forward, the sheet hauling the lee clew down and aft. The forward lower corner of a fore-and-aft sail is called the "tack," as is also the rope by which this corner is held down and secured.

Clew-lines. In taking in the sails, the clews are hauled up to the quarters of the yard by clew-lines leading from the clews to the quarter-blocks and down on deck. For topsails and courses the clew-lines are double, and reeve through a block at the clew, the standing part being clinched around the quarters of the yard.

Clew-lines or clew-ropes are fitted to trysails for hauling the clew up to the jaws of the gaff, and on gaff topsails for hauling the clew up to the head.

Leech-lines are used to haul the leeches of courses and sometimes of topsails along the yard.

Buntlines. Buntlines haul the foot of the sail above and forward of the yard for convenience in furling. They are rove through blocks at the masthead or the top rim, lead down forward and toggle to the foot of the sail some distance outside the midship line on each side.

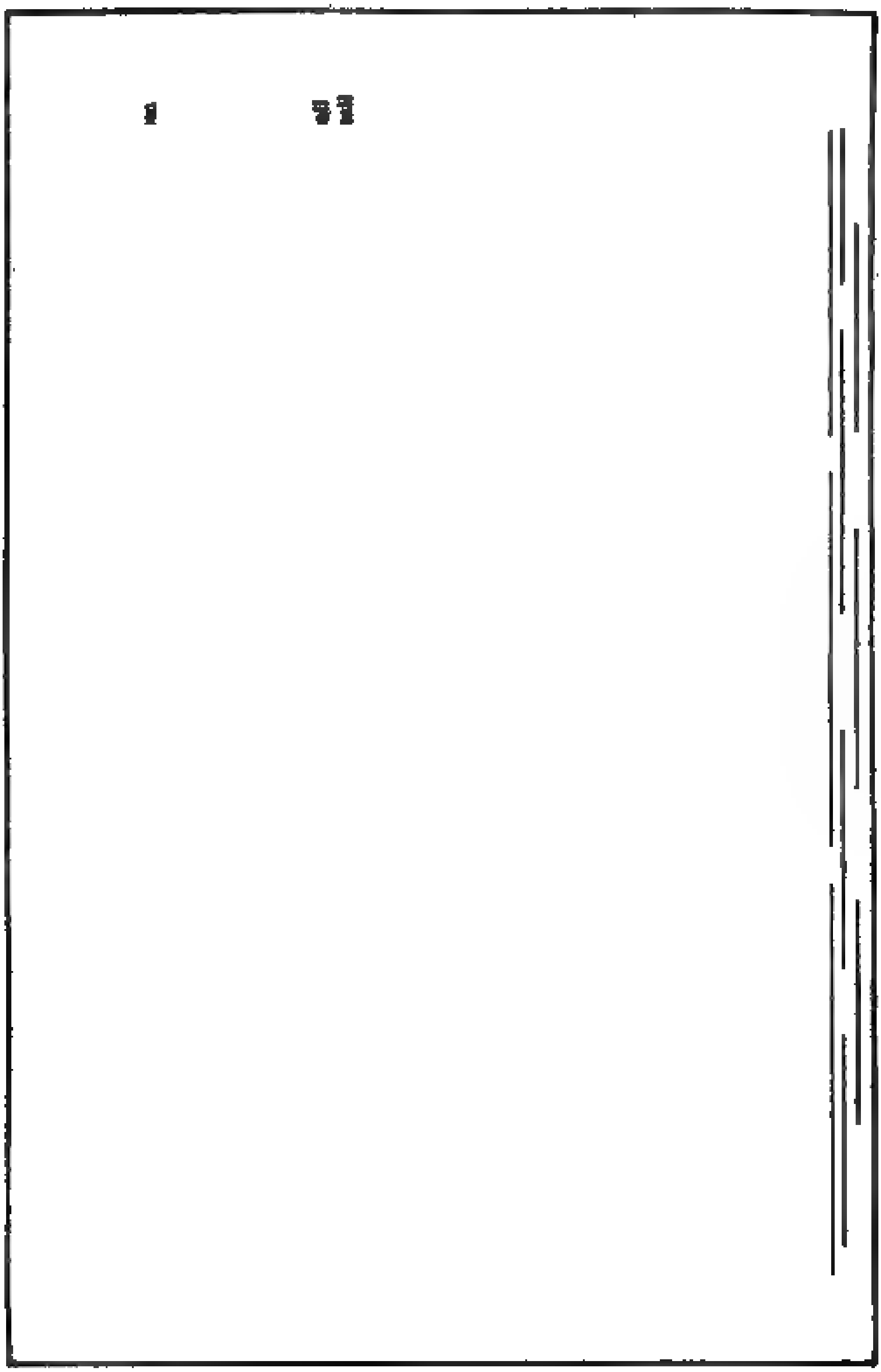
Reef-tackles. Reef-tackles are whips leading from the yard-arms of topsails and courses to cringle on the leeches of the sails, for hauling the leech up and out in reefing, affording slack for passing the earing and rousing the cringle up to its place.

Bowlines. Bowlines lead forward from the bowline bridles on the leeches of courses and topsails, and are used, when sailing on the wind, for hauling the leech well forward so that it shall hold the wind.

Outhauls. The head of a trysail is hauled out by a head outhaul, reeving through a sheave in the end of the gaff and a block at the mast, and then to the deck. The foot of a boom-sail is hauled out by a foot-outhaul reeving through a sheave in the boom.

Downhauls. Staysails are hauled down by downhauls leading from the head of the sail along the stay to a block at the tack of the sail.

The head of a trysail is hauled down by a head downhaul from the head of the sail to the jaws of the gaff.



SCHOONER UNDER SAIL.

Brails. Gaff sails—trysails, spankers, etc.—are gathered in to the mast for furling, by brails middled and stopped to the after leech, with a hauling part on each side reeving through a block on the mast at a point corresponding to the point at which they are stopped to the leech.

Vangs. Vangs are fitted to gaffs at the after end—one on each side—and led to the ship's side. Their office is to steady the gaff *when the sail is not set.*

Details of Rigging—Fore-and-Aft Rigs.

Plate **155** shows the sails and rigging of a two-masted schooner. There are many variations from this rig, especially in yachting, where special sails are used in racing and to some extent in cruising, under favorable conditions of weather. The **gaff topsail** is often replaced by a "**club-topsail,**" having the head and foot stretched out by long light spars which admit of spreading a greatly increased area of canvas. In this case the halliards are bent to the "yard" on the head of the sail near the middle point, and the yard, when hoisted to the masthead, carries the peak of the sail well up, playing the part of a topmast "pole."

A **balloon-jib** is a very large triangular sail extending from the fore-topmast head to the jib-boom end. As it has no stay, it is set "flying."

A **jib-topsail** sets on the fore-topmast stay and corresponds to the flying-jib of an ordinary schooner.

A **spinnaker** is a very large, very light triangular balloon-like sail, often made of raw silk, used in running free. The head goes to the mast-head—either fore or main—and the foot hauls out to a "**spinnaker-boom,**" temporarily rigged out on the side opposite the main-boom.

Where the spinnaker, instead of being triangular in shape, is quadrilateral, its head, always very short, hauls out on a temporary gaff rigged out for the masthead, the foot hauling out as in other cases to the spinnaker-boom. In this case the sail is called a "**shadow.**"

Various other sails—of questionable utility—are set at times by racing yachts. Such are "**water sails**" under the spinnaker boom; "**ring-tails**" increasing the area of the mainsail, etc.

The ordinary main topmast staysail is often replaced by a very large sail of the same general type as the spinnaker and the balloon jib.

§ II. TONNAGE OF SHIPS.

As there is sometimes confusion as to the difference between displacement and the several kinds of tonnage, the following definitions are given.

Displacement. The quantity or volume of water displaced by a ship is called her "displacement"; it can be expressed in either cubic feet or tons; a cubic foot of sea-water weighs 64 lbs. and of fresh water 62.5 lbs., therefore a ton is equal to 35 cubic feet of sea-water or 35.9 cubic feet of fresh water.

Tonnage, Gross Register. The total enclosed space or internal capacity of a ship, *expressed in tons of 100 cu. ft. each,* is the gross register tonnage. The unit of volume is that figure which was used originally in "Moorsom's System" of measuring ships, which system has, with slight variations in application, been adopted by most of the nations of the civilized world.

Gross register tonnage is used as a basis for calculating net register tonnage and in the United States as a basis for dry dock charges for steamers.

Tonnage, Net Register. The actual earning power of a ship is expressed by the net register tonnage and this figure is secured by deducting from the gross tonnage such spaces as may have no earning capacity; for instance, the engine, boiler and shaft alley spaces, coal bunkers, spaces used in steering and working the ship, and such spaces as may be necessary for the accommodation of the crew. The laws of the several nations vary with reference to the various deductible spaces. The Suez Canal Tonnage, although based upon the "Moorsom System," and generally similar to net register tonnage, varies therefrom in some respects.

The rules and laws which have been, from time to time, enacted in the several countries, are extensive and complicated, but are usually published in some form. For reference the following are cited:

English.—Instructions Relating to the Measurement of Ships. Issued by Board of Trade.

United States.—Navigation Laws of the U. S. Bureau of Navigation, Department of Commerce and Labor.

Suez Canal.—Reglement de Navigation dans le Canal Maritime de Suez. Suez Company.

Net register tonnage is generally used in charging harbor and port dues, canal tolls, and other similar charges to which merchant ships are liable.

§ III. SHIP'S PUMPS AND THEIR USES.

1. **Main Air Pump.** Used for pumping the air and condensed steam from the condenser into the feed-tank and thus maintaining a vacuum in the condenser. In merchant practice and some of the older naval vessels, this pump is direct-connected to the main engine.

2. **Main Circulating Pump.** Used ror circulating sea water through the condenser, and is usually of the centrifugal type. It has an independent sea-suction valve called the main injection and also a suction connection with the bilge called the bilge injection. It has a discharge through the main condenser and thence overboard through a valve called the outboard delivery. It has also a discharge leading directly from the pump overboard so that the bilge water can be pumped overboard without sending it through the condenser. Since a centrifugal pump will throw ashes, waste, etc., without clogging and also since the capacity of the circulating pump of a ship is generally far greater than the aggregate capacity of all the other bilge pumps, the circulating pumps are of great use in case a large volume of water gets into the ship from any cause. The number of circulating pumps varies according to the number of condensers.

3. **Main Feed Pump.** This is used for feeding the boilers and has suctions from the main feed tanks and reserve feed tanks, and but one delivery to the main feed line. There are one or more of these pumps according to the power and arrangement of the machinery and boilers, and located either in the engine-room or fire-room according to circumstances and the views of the designers. These pumps in merchant practice are sometimes direct connected to the main engines.

4. **Auxiliary Feed Pump.** This is used for more purposes than any other pump. It is designed primarily to be used when the main feed pump is out of repair. It can draw from the main feed tank, and reserve tank, from the bottom of the main condenser (in which case it takes the place of the air pump), from the bilge either directly or through the main or secondary drain and finally it can draw directly from the sea through its own sea valve. It can deliver either into the boilers, into the reserve feed tanks, or overboard. It should never be used on the boilers except when the main feed pump is out of order, since a leaky valve or carelessness in shutting the proper valves on the suction pipes may result in cold sea water or bilge water getting into the

boilers. The same causes may result in delivering the fresh water overboard instead of into the boiler or in pumping bilge water or salt water into a boiler instead of overboard.

This pump should not be used on the bilge oftener than absolutely necessary and after such use it should immediately be thoroughly washed out by pumping sea water overboard. The number of auxiliary feed pumps varies as in the case of main feed pumps;—there is generally one in each fire-room.

5. **Main Fire and Bilge Pump.** The principal use of this pump, as its name indicates, is for the fire and bilge service. It has an independent sea suction and delivery. At sea it is kept going slowly and continuously to keep the bilges free, and in this case other pumps are used for fire service if they are capable of supplying a sufficient quantity of water. When it becomes necessary to use the bilge pump for fire service, or for washing decks, the pump should always first be washed out by pumping sea water overboard, otherwise greasy waste and coal dust may be spread over the deck. This pump is also connected with the main and secondary drains so as to pump out the bilges or double bottom compartments of the ship. The number of these pumps varies with the size of the ship and the arrangement of the engine compartments. Such pumps are sometimes placed outside of the engine compartments and are sometimes called "wrecking" pumps.

6. **The Auxiliary Air and Circulating Pump.** This is generally a combined pump formed of two water cylinders and one steam cylinder. One of the water ends takes sea water direct from the sea and circulates it through the auxiliary condenser overboard. The other end draws fresh water from the bottom of the auxiliary condenser and delivers it into the feed tank. There are generally two auxiliary condensers, each with one combined air and circulating pump. Combined air and circulating pumps will not be used in future designs, on account of their extravagant use of steam.

7. **The Water-Service Pump.** This is a small pump used to produce a forced circulation of water through the crosshead slides and the main journals of the main engines, when the natural circulation due to the distance of the engines below the water-line is not sufficient for the purpose. It is convenient to have a connection by which this pump can deliver into the fire main, and also, into the distiller in case the distiller circulating pump should

be out of repair. There is generally one such pump in each engine compartment.

8. **The Distiller Circulating Pump.** Is used for circulating cooling water from the sea through the distillers and thence directly overboard. It usually has, however, suitable connections by which the water can be delivered into the flushing system instead of overboard and also the water can be delivered into that system without passing through the distiller if the latter should be disconnected for repair.

9. **The Fresh-Water Pump.** Is for drawing off the fresh water from the distiller and delivering it into the ship's tanks when the distiller is situated at a lower level than the tanks.

10. **The Flushing Pump.** Is used for circulating sea water through the flushing system. It often has a connection so that it can be used to circulate water through the distiller when the distiller pump is under repair. The pipes composing the flushing system are usually distinct from the fire main, but sometimes the fire main is used as part of the flushing system on a small ship.

11. **The Evaporator Feed Pump.** Is a small light-service pump for supplying salt water to the evaporators. It has a suction from the sea, and, in new designs, from the evaporator feed heaters. Its discharge is to the evaporators.

§ IV. PERMITTED DRAFT OF SHIPS. PLIMSOLL MARK.

The Plimsoll Mark is the mark painted on the sides of a ship at the middle of her length on the water-line, to indicate the drafts at which, for various conditions and types or classes of cargo-carrying vessels there will still be left a sufficient percentage of reserve buoyancy to insure the safety of the vessel. The position of this mark depends upon the type and size of the vessel. On it are indicated the maximum safe drafts for fresh and salt water, for winter and summer, and for certain oceans.

Explanation of Symbols on the Plimsoll Mark.

FW = Fresh Water.

IS = Indian Ocean in Summer.

WNA = North Atlantic in Winter (October to March inclusive).

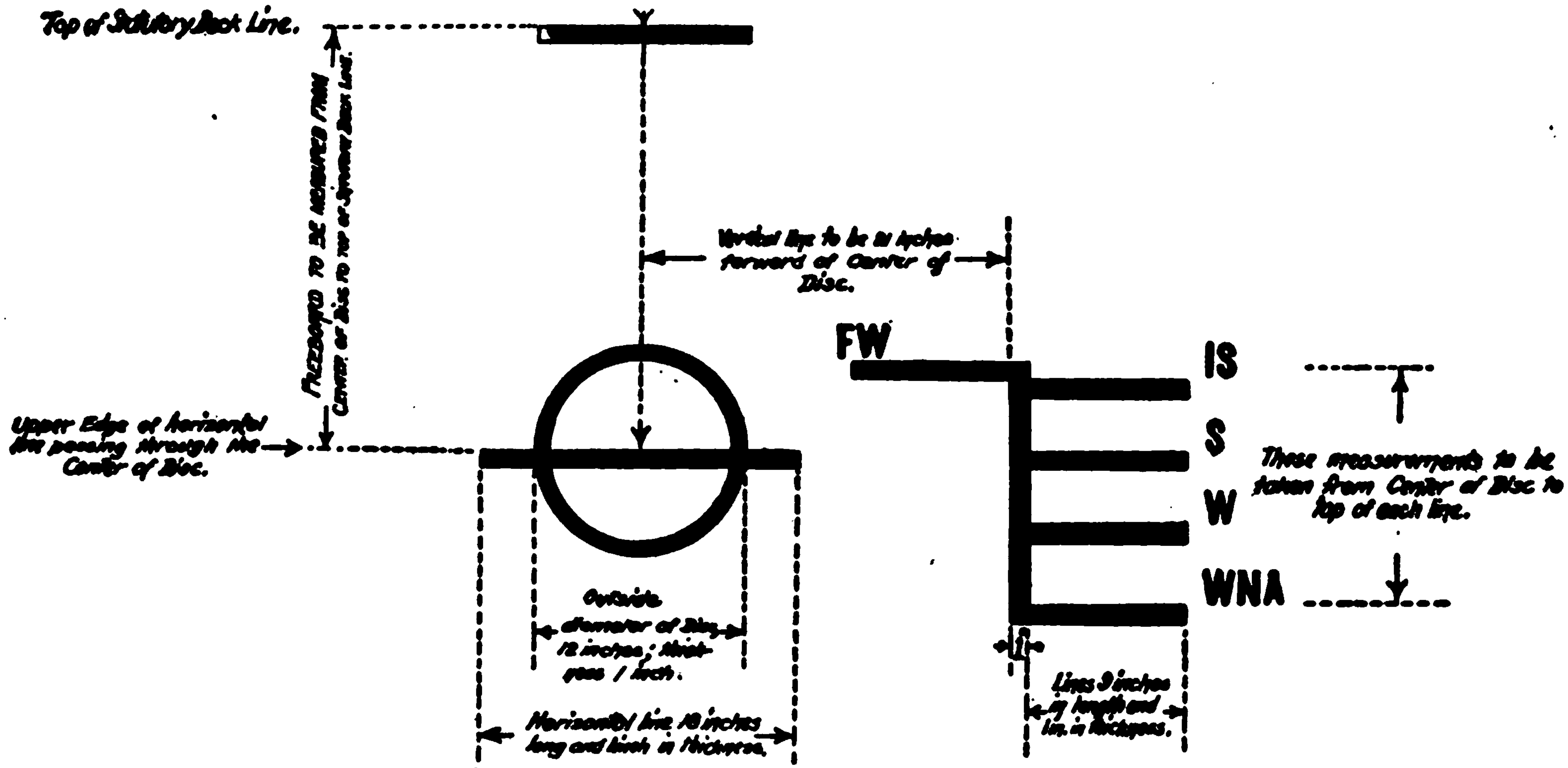
S = Summer in waters other than the Indian Ocean.

W = Winter in waters other than the North Atlantic.

All except the first of the above symbols indicate the maximum depth in salt water for the corresponding oceans and seasons.

The Mode of Marking, Approved by the Board of Trade (British), is as Follows:

FREEBOARD MARKING FOR STEAMERS.



The center of disc to be placed on both sides of vessel amidships, i. e., at the middle of the length of the load water line. Vessels are to be marked with such of the horizontal lines as are applicable to the nature of their employment. In accordance with the regulations made by the Board of Trade, the discs and the lines must be permanently marked by center punch marks or by cutting, and the particulars given in the certificate are to be entered in the official log.

§ V. DETAILS OF U. S. NAVY BOATS.

DIMENSIONS, HORSE-POWER, CAPACITY AND WEIGHTS OF BOATS AND OUTFITS

Type of Boat.	Principal Dimensions.						Horse-power.	Carrying capacity.	Approximate Weight in Pounds.									
	Length.		Extreme breadth to outside of planking.		Depth from top of gunwale to lower edge of garboard amidships.				Hull and machinery complete.	Fuel.	Lubricating oil.	Water + Stores: Water In boiler and feed tanks.	Water + Stores: Provisions	Water + Stores: Water.	Outfit ± Not part of hull.	Men in boat when hoisted.		Total hoisting weight.
	ft.	*ins.*	*ft.*	*ins.*	*ft.*	*ins.*		Men.								No.	Wt.	
Steamer	50	—	9	9[illegible]	6	2[illegible]	170	44	36,389	3,440	37	2,080	80	175	1,103	4	600	43,904
"	40	—	8	10[illegible]	5	2[illegible]	50	29	20,317	2,900	37	1,900	57	133	1,022	4	600	26,966
"	30	—	8	—	4	9[illegible]	25	25	11,325	1,162	37	1,285	50	50	356	4	600	14,865
Motor boat	35	—	7	11	4	6	100	16	9,000	506	37	....	30	64	408	4	600	10,645
Motor barge	40	—	8	6[illegible]	4	6[illegible]	150	24	12,700	750	50	....	47	110	450	4	600	14,707
Motor dory	21	—	5	9[illegible]	2	4	5	10	1,900	300	....	....	23	41	329	2	300	2,893
Motor-sailing launch	50	—	12	11	5	3[illegible]	20	190	22,281	600	37	....	333	800	1,787	4	600	26,438
" "	40	—	10	10	4	3[illegible]	20	90	11,235	600	37	....	161	400	1,058	4	600	14,091
" "	36	—	9	9½	3	9	15	70	9,697	600	37	....	126	333	1,036	4	600	12,429
" "	33	—	9	4	3	7[illegible]	10	50	7,435	375	37	....	92	266	1,025	2	300	9,530
" "	30	—	8	7[illegible]	3	5[illegible]	10	40	6,822	375	37	....	69	200	822	2	300	8,625
" "	24	—	7	1[illegible]	2	11[illegible]	10	19	4,958	375	37	....	34	83	443	2	300	6,230
Cutter	30	—	8	—	2	10	....	40	2,498	....	....	....	69	175	662	2	300	3,704
"	28	—	7	5	2	8	....	33	2,430	....	....	....	57	133	579	2	300	3,517
"	26	—	6	11	2	6	....	27	2,045	....	....	....	45	108	573	2	300	3,081
"	24	—	6	6	2	6	....	19	1,660	....	....	....	34	83	568	2	300	2,645
Whaleboat	30	—	8	2[illegible]	2	10½	....	40	2,796	....	....	....	69	175	748	14	2,100	5,888
"	28	—	7	8[illegible]	2	8	....	32	2,405	....	....	....	57	133	670	14	2,100	5,365
"	24	—	6	9[illegible]	2	5[illegible]	....	28	1,418	....	....	....	46	108	607	7	1,050	3,229
"	20	—	5	11	2	4[illegible]	....	16	1,243	....	....	....	34	83	545	6	900	2,805
Dinghy	20	—	5	6	2	1[illegible]	....	14	930	....	....	....	23	83	365	1	150	1,551
"	16	—	4	7	1	10[illegible]	....	10	423	....	....	....	23	41	331	1	150	968
Wherry	14	—	4	4[illegible]	1	7[illegible]	....	5	370	....	....	....	11	25	240	1	150	796
"	12	—	4	4[illegible]	1	6[illegible]	....	4	260	....	....	....	11	25	222	1	150	668
Punt	14	—	5	[illegible]	1	8[illegible]	....	....	606	....	....	....	....	....	75	1	150	831
"	12	—	4	2	1	8	....	....	495	....	....	....	....	....	75	1	150	720
"	10	—	3	7	1	5[illegible]	....	....	413	....	....	....	....	....	75	1	150	638

§ VI. ROPE, U. S. NAVY.

Manila Rope, Plain Laid.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
6 thread, 3/4 inch	0.12	250	30	700	
9 thread, 1 inch	.20	150	30	1,100	
12 thread, 1 1/8 inch	.25	120	30	1,500	
15 thread, 1 1/4 inch		100	30	1,800	
18 thread, 1 3/8 inch		150	52	2,000	
21 thread, 1 1/2 inch		200	100	2,500	
1 3/4-inch		200	120	3,000	
2-inch		200	167	4,000	
2 1/4 inch		200	204	5,000	
2 1/2-inch		150	190	5,550	
2 3/4 inch		150	225	6,600	
3-inch		150	277	7,800	
3 1/4-inch		150		9,200	
3 1/2-inch	2.54	150		10,600	
3 3/4-inch	2.80	150		12,200	
4-inch	3.25	150		13,700	
4 1/4-inch	3.66	150		14,900	
4 1/2-inch	4.00	150		17,400	
4 3/4 inch	4.40	150		19,000	
5-inch	5.00	150		21,800	
5 1/4 inch	5.60	150		23,700	
5 1/2-inch	6.00	150		27,700	
6-inch	7.24	150		31,000	
6 1/2-inch	8.48	150		33,500	
7-inch	9.80	150		36,200	
7 1/2-inch	11.20	150		42,300	
8-inch	13.00	150		47,300	
8 1/2-inch	14.40	150		54,200	
9-inch	16.20	150		60,000	
9 1/2-inch	18.00	150		67,000	
10-inch	20.00	150		74,200	

Manila Hemp, Plain Laid, Hawsers.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
5-inch	5.33	120	640	21,800	These may be made in any size, but not in longer lengths than 150 fathoms, the length of the ropewalk. The strands are hauled a little longer and the rope closed up with more afterturn, making it a little fuller than plain laid rope of the same size. These hawsers are hauled out longer than 120 fathoms to allow for fag ends, which are not cut off, and for a splice which is not made, but the weight is charged to 120 fathoms, making it heavier than plain laid rope of same size.
6-inch	7.90	120	950	31,000	
7-inch	10.40	120	1,250	36,200	
8-inch	13.30	120	1,600	47,300	
9-inch	17.20	120	2,060	60,000	
10-inch	22.16	120	2,660	74,200	

American Hemp Rope, Tarred, Plain Laid, Three Strand.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
¾-inch	0.31	200	62	750	Note that this may be made to any size if required. It is, however, seldom or never called for in larger sizes.
1-inch	.36	200	72	1,060	
1¼-inch	.40	200	80	1,670	
1½-inch	.50	200	100	2,340	
1¾	.63	200	126	3,325	
2-inch	.96	200	192	3,955	
2¼	1.28	200	256	4,718	
2½-inch	1.56	150	235	5,770	
2¾-inch	1.90	150	285	7,000	
3-inch	2.24	150	336	8,380	
3¼-inch	2.66	150	400	9,770	
3½-inch	3.06	150	460	11,200	
3¾-inch	3.53	150	530	13,000	
4-inch	4.00	150	600	14,550	

Ratline Stuff and Similar Material Made up on Special Orders of Tarred American Hemp.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
6-thread, ¾-inch	0.18	100	18	650	
9-thread, 1-inch	.25	100	25	1,120	
12-thread, 1⅛-inch	.35	100	35	1,500	
15-thread, 1¼-inch	.45	100	45	1,800	
18-thread, 1⅜ inch	.53	100	53	2,100	
21-thread, 1½-inch	.60	100	60	2,400	
24-thread, 1⅝-inch	.70	100	70	2,650	

American Hemp, Tarred, Bolt Rope.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
1-inch	0.27	100	27	1,120	
1¼-inch	.37	100	37	1,780	
1½-inch	.53	100	53	2,470	
1¾-inch	.70	100	70	3,500	
2-inch	.94	100	94	4,300	
2¼-inch	1.18	100	118	5,550	
5½-inch	1.50	100	150	6,790	
2¾-inch	1.75	100	175	8,220	
3-inch	2.11	100	211	9,800	
3¼-inch	2.44	100	244	11,493	
3½-inch	2.84	100	284	13,220	
3¾-inch	3.33	100	333	15,300	
4-inch	3.72	100	372	17,000	
4¼-inch	4.25	100	425	19,600	
4½-inch	4.74	100	474	22,050	
4¾-inch	5.38	100	538	24,400	
5-inch	6.00	100	600	26,900	

American Hemp Rope, Tarred, Plain Laid, Four-strand.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
1¼-inch	0	200	[illegible]	1,800	Note that this rope is made up in four strands only on special orders.
1½-inch		200	[illegible]	2,400	
2-inch		200	[illegible]	3,085	
2¼-inch	1	200	[illegible]	4,340	
2½-inch	1	150	[illegible]	5,250	
2¾-inch	1	150	[illegible]	6,253	
3-inch	2	150	[illegible]	7,560	
3¼-inch	2	150	[illegible]	8,570	
3½-inch	3	150	[illegible]	10,290	
3¾-inch	3	150	[illegible]	11,812	
4-inch	4	150	[illegible]	12,440	
4¼-inch	4	150	[illegible]	15,170	
4½-inch	5	150	[illegible]	17,010	
4¾-inch	5	150	[illegible]	18,962	
5-inch	6	150	[illegible]	21,000	
5¼-inch	7	150	1,	23,152	
5½-inch	7	150	1,	25,410	
5¾-inch	8	150	1,	28,773	
6-inch	9	150	1,	30,240	
6½-inch	10	150	1,	35,533	
7-inch	12	150	1,	40,202	
7½-inch	14	150	2,	46,350	
8-inch	[illegible]	150	2,	53,172	
8½-inch	[illegible]	150	2,	60,480	
9-inch	21	150	3,	67,040	

Seizing Stuff—Tarred American Hemp.

Name and circumference.	Weight per fathom.	Length of coil.	Weight of coil.	Breaking strain.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	*Pounds.*	
4-thread, [illegible]-inch	0 095	100	50	365	5 lengths to package.
6-thread, [illegible]-inch	12	100	50	560	4 lengths to package.
9 thread, [illegible]-inch	.155	100	50	700	3 lengths to package.
12-thread, 1-inch	.21	100	60	955	3 lengths to package.

Lead Lines.

Name and circumference.	Material.	Weight per fathom.	Length of coil.	Weight of coil.
		Pounds.	*Fms.*	*Pounds.*
Boat lead line, [illegible]-inch	Cotton twine, braided	0 07	25	1 75
Ship's lead line, [illegible]-inch	Flax twine, braided	14	33⅓	4 67
Coasting lead line, 1-inch.	do	.16	100	16 00
Deep-sea lead line, 1[illegible] inch.	Am. hemp, plain laid.	.47	150	70.50

Log Lines.

Name and circumference.	Material.	Weight per fathom.	Length of coil.	Weight of coil.
		Pounds.	*Fms.*	*Pounds.*
Chip log line, [illegible]-inch	American hemp.	0.15	100	15.00
Taffrail log line, [illegible]-inch	Cotton twine, braided	.14	33⅓	4.67
Do.	do.	.14	66⅔	9.34
Do.	do.	.14	100	14.00

Cotton Lines.

Name and circumference.	Weight of coil.	Length of coil.	Weight per fathom.	Remarks.
	Pounds.	*Fms.*	*Pounds.*	
72 thread, 8 ply, 1 1/16-inch..	30	115	0.26	
54-thread, 8 ply, 1-inch...	30	160	.19	
45-thread, 8 ply, 7/8-inch...	30	200	.154	
30-thread, 8 ply, 11/16-inch...	30	260	.11	
24-thread, 8 ply, 9/16-inch...	10	110	.09	Wound in 10-pound packages; 6 packages packed for shipment in bale weighing 60 pounds.
18-thread, 6 ply, 1/2-inch....	10	250	.04	
15-thread, 6 ply, 1/2-inch....	10	280	.035	
15-thread, 4 ply, 7/16-inch...	10	330	.03[1]	

[1] For clothes stops.

Miscellaneous Small Stuff.

Cod line of untarred American hemp weighing 0.09 pound per fathom and made up in 10-pound coils, one of which suffices for 10 sets of hammock clews, this being the purpose for which this material is issued: 6 packages packed for shipment in bale weighing 60 pounds.

Match rope is made up in 1-pound packages and put in sealed tin cans.

Untarred marline for sennit is made up in 10-pound coils, weight per fathom, 0.028 pound; six packages packed for shipment in bale weighing 60 pounds.

Yacht marline is tarred; is used for small work in rigging lofts; weight per fathom, 0.0195 pound; length of 60 fathoms; weight, 1.17 pounds; coil, 20 pounds, or as required.

Marline tarred.—Weight per fathom, 0.0327 pound; lengths of 65 fathoms; weight, 2.125 pounds; coil, 20 pounds, or as required.

House line. Weight per fathom, 0.0519 pound; lengths of 65 fathoms; weight, 3.375 pounds; coil, 20 pounds, or as required.

Round line. Weight per fathom, 0.066 pound; lengths of 60 fathoms; weight, 4 pounds; coil, 50 pounds, or as required.

Spun Yarn, 2-yarn. Weight per fathom, 0.528 pound; length of 65 fathoms; weight, 3.437 pounds; coil, 50 pounds, or as required.

Spun Yarn, 3-yarn. Weight per fathom, 0.073 pound; lengths of 65 fathoms; weight 4.75 pounds; coil, 50 pounds, or as required.

Manila Rope.

Manila rope to be of the grade known to the trade as "Rope made of selected yarns,", viz. yarn to be spun of long-fiber manila hemp of a grade not inferior to the mark SB/CS or of selected fiber equal to that mark.

Rope from 3/4-inch circumference, 6-thread to 3 inches circumference, inclusive, to be made 3-strand; 3½ inches circumference and above to be made 4-strand unless otherwise specified. For the rapid handling of loads of about 900 pounds, such as coaling whips, a 4½-inch circumference manila rope is recommended.

Hemp Rope.

Hemp rope to be made from the best quality double-dressed American hemp, free from barr and tow, all rope to be tarred except for cod line or

hammock clew stuff and white martine. It may be 3 or 4 strand, as required, but 3-strand is not usually made larger than 4 inches, except for bolt rope, which is always 3-strand.

Specifications, Where Obtainable.

Note. Copies of the above specifications can be obtained upon application to the Bureau of Supplies and Accounts, Navy Department, Washington, D. C.

Galvanized Steel Wire Rope.

Type A.

Composed of 6 strands, with a hemp core, 19 wires to a strand; or 18 wires, with a center of jute, cotton, or hemp twine.

Diameter	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
5/16-inch	1-inch	0.90	90	6,170	Standing rigging
3/8-inch	1⅛-inch	1.27	127	8,740	Guys.
7/16-inch	1⅜-inch	1.71	171	11,760	Boat slings. Running rigging 7/16-inch and less.
½-inch	1½-inch		223	1[illegible]	Topping lifts.
9/16-inch	1¾-inch		280	1[illegible]	(For coaling booms.)
⅝-inch	2-inch		360	2[illegible]	
¾-inch	2¼-inch		507	3[illegible]	Wheel ropes.
13/16-inch	2½-inch		594	4[illegible]	(9/16-inch and under.)
⅞-inch	2¾-inch		688	4[illegible]	
1-inch	3-inch		900	6[illegible]	
1 1/16-inch	3¼-inch		1,080	7[illegible]	
1⅛-inch	3½-inch		1,160	7[illegible]	
1 3/16-inch	3¾-inch		1,300	8[illegible]	
1¼-inch	4-inch		1,446	9[illegible]	
1 5/16-inch	4¼-inch		1,730	11[illegible]	
1⅜-inch	4½-inch		1,880	12[illegible]	
1 7/16-inch	4¾-inch		2,036	13[illegible]	
1½-inch	5-inch		2,323	16[illegible]	

Plow Steel Wire Rope.

Type A.

Composed of 6 strands, with a hemp core, 19 wires to a strand; or 18 wires, with a center of jute, cotton, or hemp twine.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
⅜-inch	1⅛-inch	1.27	127	10,340	
½-inch	1½-inch	2.23	223	18,000	
⅝-inch	2-inch	3.60	360	29,160	
¾-inch	2¼-inch	5.07	507	41,350	
⅞-inch	2¾-inch	6.88	688	55,640	
1-inch	3-inch	9.00	900	72,040	
1⅛-inch	3½-inch	11.60	1,160	93,040	
1¼-inch	4-inch	14.46	1,446	116,690	
1 5/16-inch	4¼-inch	18.80	1,880	152,430	

Galvanized Steel Wire Rope.

Type B.

Composed of 6 strands and a hemp core, each strand consisting of 12 wires and a hemp center.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
[illegible]-inch	[illegible]	[illegible]		[illegible]	
[illegible]-inch	[illegible]	[illegible]		[illegible]	Life lines.
[illegible]-inch	[illegible]	[illegible]		[illegible]	Guys.
[illegible]-inch	[illegible]	[illegible]		[illegible]	Ridge ropes.
[illegible]-inch	[illegible]	[illegible]		1 [illegible]	Boat ladders.
[illegible]-inch	[illegible]	[illegible]		[illegible]	Jacob's ladders.
[illegible]-inch	2[illegible]	[illegible]		1 [illegible]	Gunport lanyards.
[illegible]-inch	2[illegible]	[illegible]		[illegible]	Boom pendants.
[illegible]-inch	2[illegible]	[illegible]		[illegible]	Running rigging.
[illegible]-inch	3[illegible]	[illegible]		[illegible]	
1-inch	3[illegible]	[illegible]		4 [illegible]	
1 [illegible]-inch	3[illegible]	[illegible]		5 [illegible]	
1 [illegible]-inch	3[illegible]	[illegible]		5 [illegible]	
1 [illegible]-inch	3[illegible]	[illegible]		[illegible]	
1 [illegible]-inch	4[illegible]	[illegible]		7 [illegible]	
1 [illegible]-inch	4[illegible]	[illegible]		8 [illegible]	
1 [illegible]-inch	4[illegible]	[illegible]		9 [illegible]	
1 [illegible]-inch	4[illegible]	[illegible]		10 [illegible]	
1 [illegible]-inch	5[illegible]	[illegible]		12 [illegible]	

Galvanized Steel Wire Rope.

Type AA.

Composed of 6 strands, with a hemp core, each strand consisting of 37 wires, or 36 wires with a hemp, jute, or cotton center.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
[illegible]-inch	1[illegible]	1.32	132	[illegible]	Towing hawsers; crane falls; bridles, large and small, tiller ropes; tiller ropes on ships' boats; cat and fish pendants; clear hawse pendants, dip ropes; torpedo slings, and slings for general hoisting.
[illegible]-inch	1[illegible]	1 [illegible]	180	1 [illegible]	
[illegible]-inch	1[illegible]	2.34	234	1 [illegible]	
[illegible]-inch	1[illegible]	3 00	300	1 [illegible]	
[illegible]-inch	2[illegible]	3 72	372	[illegible]	
[illegible]-inch	2[illegible]	5 34	534	[illegible]	
[illegible]-inch	2[illegible]	7 20	720	4 [illegible]	
1-inch	3[illegible]	9.48	948	[illegible]	
1 [illegible]-inch	3[illegible]	12 00	1,200	[illegible]	
1 [illegible]-inch	4[illegible]	14 70	1,470	[illegible]	
1 [illegible]-inch	4[illegible]	18 00	1,800	11 [illegible]	
1 [illegible]-inch	4[illegible]	21 30	2,130	13 [illegible]	
1 [illegible]-inch	5[illegible]	24 90	2,490	15 [illegible]	
1 [illegible]-inch	5[illegible]	29 10	2,910	18 [illegible]	
2-inch	6[illegible]	37 80	3,780	24 [illegible]	
2 [illegible]-inch	7[illegible]	48 00	4,800	29 [illegible]	

PLOW STEEL WIRE ROPE.

Type AA.

Composed of 6 strands, with a hemp core, each strand consisting of 37 wires, or 36 wires with a hemp, jute, or cotton center.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
⅜-inch	1⅛-inch	1.32	132	10,000	Transmission rope for steering gear; boat crane falls; crane falls, afloat and ashore; hawsers, where great strength is required, relieving tackles.
½-inch	1½-inch	2.34	234	19,300	
⅝-inch	2-inch	3.72	372	27,790	
¾-inch	2¼-inch	5.34	534	40,000	
⅞-inch	2¾-inch	7.20	720	54,400	
1-inch	3-inch	9.48	948	71,100	
1⅛-inch	3½-inch	12.00	1,200	90,000	
1⅝-inch	5-inch	24.90	2,490	183,000	
2-inch	6¼-inch	37.80	3,780	284,500	

GALVANIZED STEEL WIRE ROPE.

Type BB.

Composed of 6 strands and a hemp core, each strand consisting of 30 wires around a center of hemp, jute, or cotton twine.

Strength, 10 per cent less than that of galvanized steel wire rope, type A. Sufficient data have not been obtained to tabulate this type to any extent.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
⅜-inch	1⅛-inch	1.20	120	8,060	
½-inch	1½-inch	2.00	200	15,500	
⅝-inch	2-inch	3.30	330	22,390	
¾-inch	2¼-inch	4.80	480	32,240	

NAVY STANDARD MOORING HAWSERS.

Type C.

Composed of 6 strands with a hemp core, each strand consisting of 14 wires and a center of hemp or jute yarn.

Large eye splice fitted at one end and thimble in opposite end to attach to reel.

Diameter.	Approximate circumference.	Weight per fathom.	Weight per coil, 100 fathoms.	Breaking strain, pounds.	Use.
13/16-inch	2½-inch	......	447	28,400	Note that Navy standard mooring hawsers may be made in the following lengths: 1⅛-inch, 640 fathoms; 1¼-inch, 490 fathoms; 1 7/16-inch, 375 fathoms; 1⅝-inch, 300 fathoms.
1-inch	3-inch	......	644	41,500	
1⅛-inch	3½-inch	......	830	53,740	
1¼-inch	4-inch	......	1,080	69,380	
1 7/16-inch	4½-inch	......	1,377	87,000	
1⅝-inch	5-inch	......	1,750	113,700	

Galvanized Annealed Steel Wire Seizing Stuff.

Diameter.	Weight per fathom.	Weight per coil.	Length of coil, fathoms.	Breaking strain, pounds.	Wires.	
1/16-inch	0.06	50	830	268	7	
3/32-inch	.12	50	415	558	7	
1/8-inch	.20	50	250	960	7	
5/32-inch	.30	50	166	1,475	7	
3/16-inch	.50	100	200	2,300	19	
1/4-inch	.80	100	125	3,790	19	

Phosphor-bronze Wire Rope.

Type A. Used for periscope guys and nets on masts.

Type B. Used for life lines (destroyers and submarines), awning ridge ropes, etc.

Silicon-bronze Wire Ropes.

Used as an economical substitute for phosphor-bronze wire rope for life lines (destroyers and submarines).

Antennæ wires for aerials.

Wire for Navigational Sounding Machines.

Diameter, 0.063 inch; 7 wires of 0.021 inch diameter, 300 fathoms long; gross weight, 19 pounds; in sealed tin cans.

Wire Rope.

1. Wire rope is measured by its diameter in inches.

2. When used over a sheave, the diameter of the sheave should be more than 15 times the diameter of the rope, and the less flexible the rope the larger should be the sheave. Ordinary commercial practice is to allow 1 foot diameter of sheave for each ¼ inch diameter of rope.

3. It will be made for general service of 6 strands around a jute or hemp center, in 3 types—A, B, and C—but for special purposes, where greater flexibility, combined with strength, is required, it may be made of types AA and BB.

4. Type A is plain laid, the strands being made of 6 wires around a heart of hemp, jute, cotton, or a single annealed wire. Around this core are wrapped 12 wires, making 18 wires in the strand and 108 wires in the rope. The strands are laid up around a hemp center about the diameter of the strand. The smallest rope is made of this type, and the size of the wire used depends upon the size of the rope required. This is the strongest and most durable wire rope made, but is the most inflexible. It is used for standing rigging, and may be used for wheel and running rigging of 7/16 inch and less, and for any other purpose where strength alone is required or where the sheave or barrel over which it is to be used can be made very large in proportion to the diameter of the rope.

5. Type AA is made the same as type A, with the addition of another wrap of 18 wires, making 36 wires in the strand and 216 in the rope. It can be ⅜ inch and larger. This type has almost the tensile strength of A, but

is much more flexible. It is not recommended in the smaller sizes, where type A will answer the same purpose, for it is not so durable, and, being made of smaller wires, they chafe off soon, making the rope ragged and hard on the hands. It may be used in larger sizes for crane falls, special hawsers, etc., where great strength, combined with flexibility, is required.

(*a*) If greater strength still is required in the smaller diameter, the 6 strands can be laid around a seventh strand of the same kind, instead of a hemp center, which increases the strength about one-seventh, and the weight of the rope about one-sixth, but makes it less flexible.

7. Type B is plain laid, the strands being made of 12 wires around a core of jute or cotton twine, making 72 wires in the rope. The strands are laid up around a hemp or jute center about the size of the strand. This type is more flexible, but has less tensile strength than A, and is used for running rigging. The type is made ¼ inch and larger, but for special purposes can be made as small as $\frac{3}{16}$ inch by reducing the number of wrap wires.

8. Type BB is made the same as type B, with the addition of another wrap of 18 wires, making 30 in the strand and 180 in the rope. It is more flexible than any of the foregoing and has almost the tensile strength of A. It should be used in the larger sizes, where great flexibility is required. It can also be used where especially flexible hawsers are required, but will not have the durability of either A, B, or C.

9. Type C is plain laid, the strands being made of 14 wires in one wrap around a core of jute twine, making 84 wires in the rope. This type gives the maximum flexibility, except BB; is not made in sizes less than $\frac{11}{16}$ inch, and is used for hawsers. All hawsers are made this type, unless otherwise specified, and it is not carried in stock for any other purpose.

10. Any of the foregoing ropes can be made of annealed-steel wire, which would give them greater flexibility, but only about one-half of the tensile strength. The crucible-steel wire used has a tensile strength of not less than 220,000 pounds to the square inch, while the annealed has not less than 110,000 pounds. For plow steel rope, a tensile strength of 260,000 pounds per square inch and an elongation in 10 inches of at least 2½ per cent are required. Tensile strength of phosphor-bronze wire used for rope making is 120,000 pounds per square inch. Tensile strength of silicon-bronze wire is 85,000 to 100,000 pounds per square inch. Silicon-bronze wire has nearly the strength of phosphor-bronze wire and is more ductile, equal in conductivity, and to date lower in price. There is a loss, owing to the lay, from 15 per cent in type B to 20 per cent in type A.

11. Seizing is made of galvanized annealed steel, 6 wires around a single wire heart. Navigational sounding wire is made the same way, of galvanized hard steel wire.

12. These types cover all the rope in general uses in the service, but other kinds can be made, and in case they are required a full description or samples should be given, the uses to which they are to be put, with diameter of drum or sheave over which to be used, when some discretion can be used, in case the actual kind required can not be made.

13. No wire smaller than 0.016 inch diameter is carried in stock, and where smaller is required it is better to purchase the rope outside.

14. Ungalvanized steel and iron wire are not carried in stock, as they

are seldom called for. They can be procured however, if rope is required of them in sufficient quantities to authorize purchases.

Deterioration of Wire Rope.

15. The principal causes of deterioration of wire rope are heavy abrasion, overstrain, bending, and corrosion. Evidence of abrasion is shown by the outside wires wearing thin in a short time. If the wires are little worn, break off squarely, sticking out all over the rope, there is evidence of an overload or severe bending.

Factor of Safety.

16. A factor of safety of not less than 5 is recommended. For cranes and falls upon which there is sudden and repeated stress, it is safer to figure a factor of safety upon the elastic limit of the material rather than upon the tensile strength.

Lubrication.

17. The wear upon a running rope is both external and internal, and as it is impossible in the manufacture of the rope to provide lubrication for the entire life of the rope it becomes necessary to use a lubricant of such a nature that it will penetrate to the center of the rope. A heavy-bodied oil with good black lead is a good lubricant and is cheaper and as satisfactory as any of the proprietary lubricants. A heavy viscous preparation covering the outside of the rope does not give the internal lubrication necessary.

§ VII. BUOYAGE.

Plates **156**, **157**, and **158** show the systems of buoyage at present used by the principal maritime powers. These plates are put here rather than in Chapter XIV because they are subject to change.

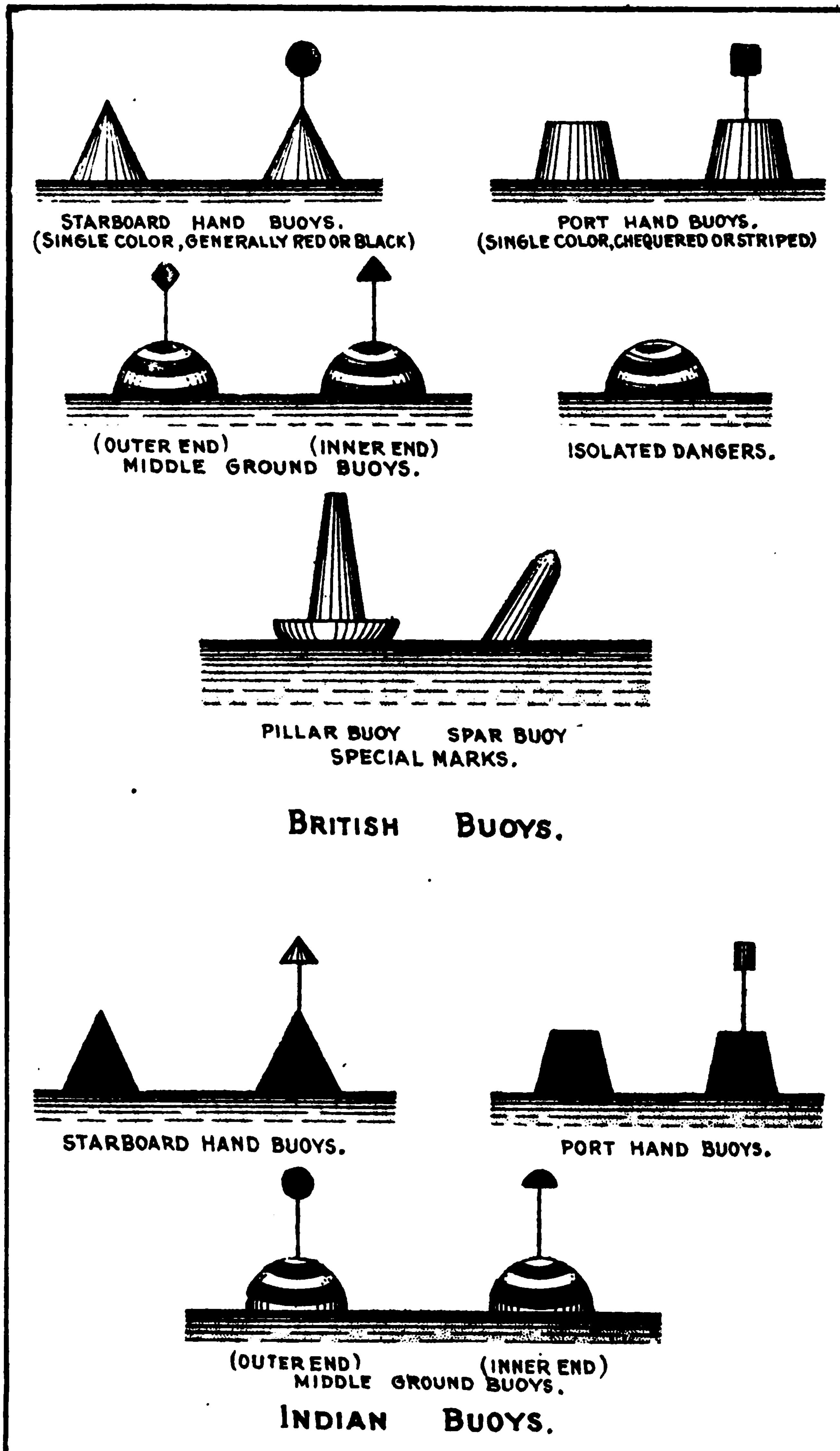
§ VIII. DIRECTIONS FOR RESTORING THE APPARENTLY DROWNED.

THE SCHAFER METHOD. Plate 159.

1. Generally speaking, the same steps are followed in the Schafer Method as in any other method; namely, remove the water from the lungs, clear the air passages, restore breathing, remove wet clothing, and stimulate by heat and friction. The difference between the Schafer Method and the Sylvester Method, which has heretofore been generally recommended and practiced, is in the manner of restoring respiration.

The simplest method whereby water may be removed from the lungs, and incidentally from the stomach, which often contains considerable water which has been swallowed, is by placing the patient face down, clasping your hands under his abdomen and

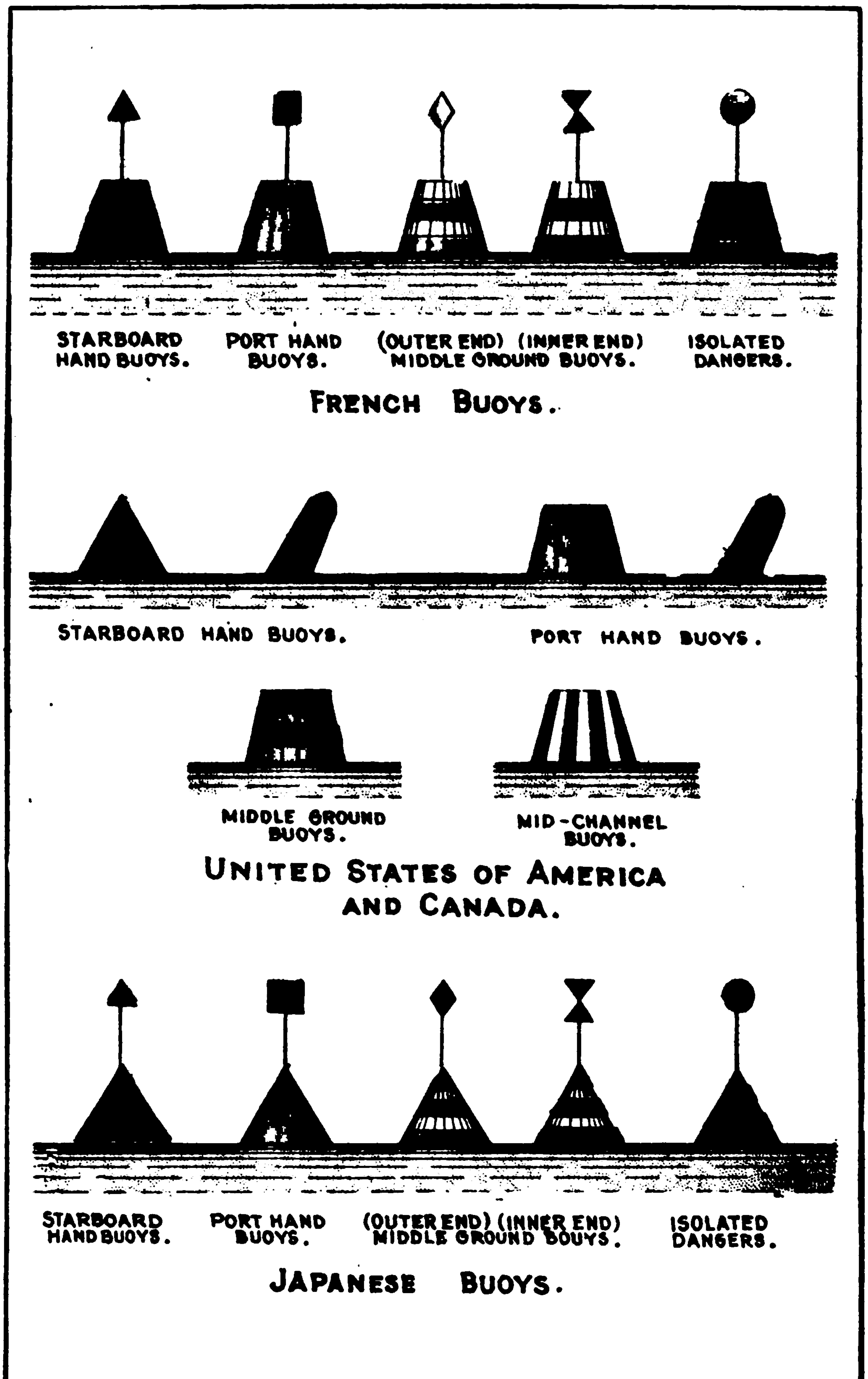
Plate No. 156.



BUOYAGE.

(*Facing page* 698)

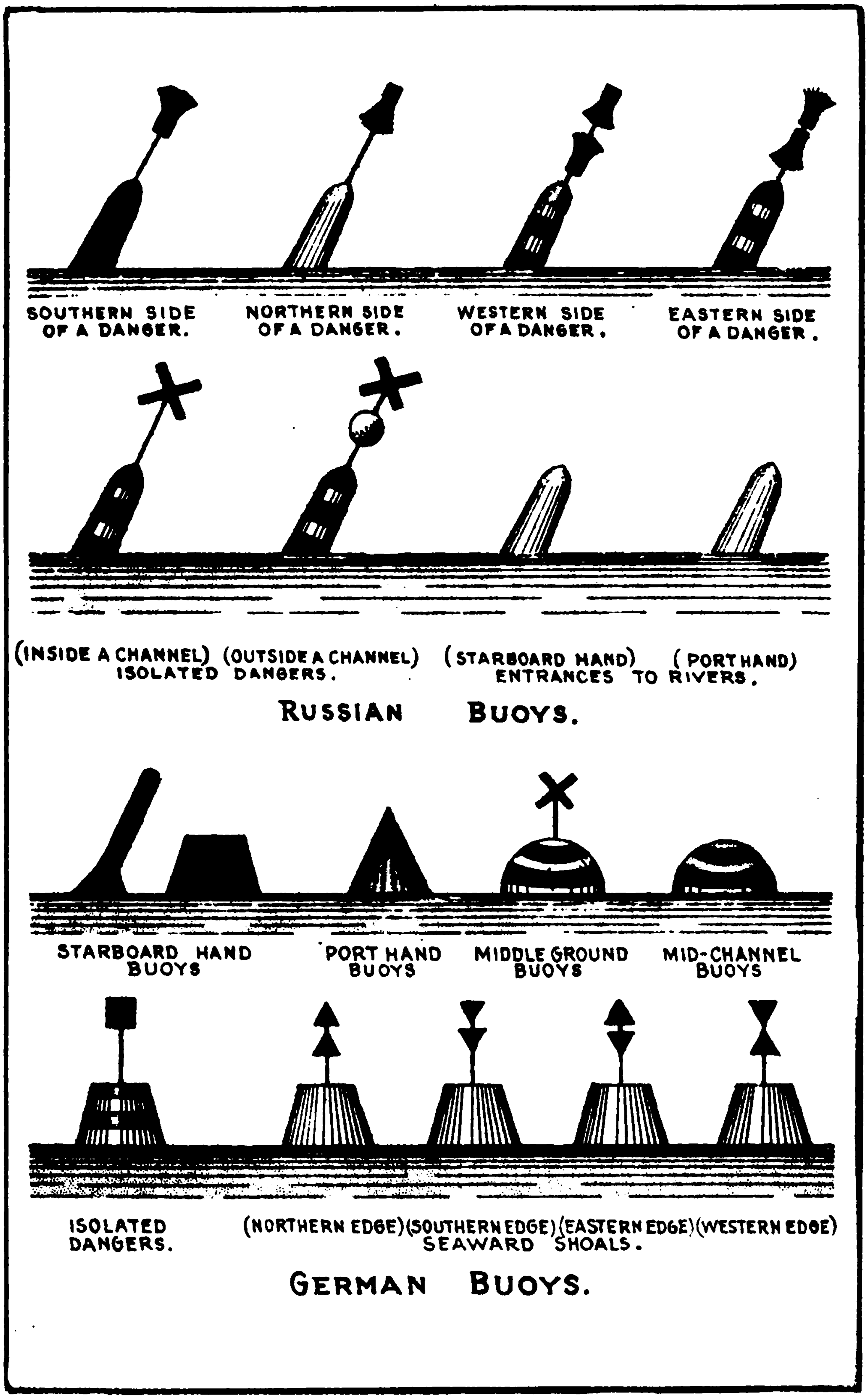
Plate No. 157.



BUOYAGE.

(Facing page 698)

Plate No. 158.



BUOYAGE.

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raising him sufficiently to permit the water to run from the air passages, lungs and stomach.

SCHAFER METHOD OF RESTORING RESPIRATION.

2. After removing water from the lungs and clearing the air passages, place the patient on his abdomen with his face protected by clothing and turned to one side so that the mouth and nose are free for breathing. Kneel beside him, or, if preferred, astride him, with your knees at his hips, and facing towards his head; place the palms of your hands on the small of his back, the base of the palms in line with the spinal column, thumbs extended and nearly touching and fingers slightly extended. First movement: Lean forward and gradually bring the weight of your body on your hands, the movement taking two or three seconds. Avoid all approach to roughness, such as might injure the internal organs. The object of the movement is to compress the lower part of the chest and abdomen, forcing the air and water out of the lungs. Second movement: Swing backward, releasing the pressure quickly but leaving your hands in place. The object of this movement is to allow the lungs to expand with the release of pressure and therefore for air to rush in to fill up the air spaces of the lungs. These two movements of compression and release simulate natural breathing and the movements should be so regulated as to be completed about fifteen times to the minute, each double movement occupying about four seconds. Continue the artificial respiration until the patient breathes, and for a while after signs of returning life, carefully aiding the first short gasps until deepened into full breaths.

AFTER TREATMENT.

3. *Externally:* As soon as breathing is established let the patient be stripped of all wet clothing, wrapped in blankets only, put to bed comfortably warm, but with a free circulation of fresh air, and left to perfect rest. The warmth of the body may be promoted by brisk rubbing of the limbs, the rubbing being always *toward* the body, by the application of hot flannels to the stomach and armpits, and bottles of hot water, heated bricks, etc., to the limbs and soles of the feet.

Internally: Give whisky or brandy and hot water in doses of a teaspoonful to a tablespoonful every ten or fifteen minutes

Plate No. 159.

TO REMOVE WATER FROM LUNGS.

TO RESTORE RESPIARTION—FIRST MOVEMENT.

TO RESTORE RESPIRATION—SECOND MOVEMENT.

REVIVING THE APPARENTLY DROWNED.

for the first hour, and as often thereafter as may seem expedient. If neither whisky nor brandy is at hand, some other stimulant may be substituted.

LATER APPLICATIONS.

4. After reaction is fully established there is great danger of congestion of the lungs, and if perfect rest is not maintained for at least forty-eight hours it sometimes occurs that the patient is seized with great difficulty of breathing, and death is liable to follow unless immediate relief is afforded. In such cases apply a large mustard plaster over the breast. If the patient gasps for breath before the mustard takes effect, assist the breathing by carefully repeating the artificial respiration.

§ IX. INSTRUCTIONS FOR SAVING DROWNING PERSONS BY SWIMMING TO THEIR RELIEF.

1. When you approach a person drowning in the water assure him with a loud and firm voice that he is safe.

2. Before jumping in to save him, divest yourself as far and as quickly as possible of all clothes; tear them off if necessary; but if there is not time, loose at all events the foot of your drawers, if they are tied, as, if you do not do so, they fill with water and drag you.

3. On swimming to a person in the sea, if he be struggling do not seize him then, but keep off for a few seconds till he gets quiet, for it is sheer madness to take hold of a man when he is struggling in the water, and if you do you run a great risk.

4. Then get close to him and take fast hold of the hair of his head, turn him as quickly as possible onto his back, give him a sudden pull, and this will cause him to float, then throw yourself on your back also and swim for the shore, both hands having hold of his hair, you on your back and he also on his, and of course his back to your stomach. In this way you will get sooner and safer ashore than by any other means, and you can easily thus swim with two or three persons; a good swimmer has, as an experiment, done it with four, and gone with them 40 or 50 yards in the sea. One great advantage of this method is that it enables you to keep your head up and also to hold the person's head up you are trying to save. It is of primary importance that you take fast hold of the hair and throw both the person and

yourself on your backs. After many experiments, it is usually found preferable to all other methods. You can in this manner float nearly as long as you please, or until a boat or other help can be obtained.

5. It is believed there is no such thing as a *death grasp;* at least it is very unusual to witness it. As soon as a drowning man begins to get feeble and to lose his recollection, he gradually slackens his hold until he quits it altogether. No apprehension need, therefore, be felt on that head when attempting to rescue a drowning person.

6. After a person has sunk to the bottom, if the water be smooth, the exact position where the body lies may be known by the air bubbles, which will occasionally rise to the surface, allowance being of course made for the motion of the water, if in a tideway or stream, which will have carried the bubbles out of a perpendicular course in rising to the surface. Oftentimes a body may be regained from the bottom, before too late for recovery, by diving for it in the direction indicated by these bubbles.

7. On rescuing a person by diving to the bottom, the hair of the head should be seized by one hand only, and the other used in conjunction with the feet in raising yourself and the drowning person to the surface.

8. If in the sea, it may sometimes be a great error to try to get to land. If there be a strong "outsetting" tide, and you are swimming either by yourself or having hold of a person who can not swim, then get on your back and float till help comes. Many a man exhausts himself by stemming the billows for the shore on a back-going tide, and sinks in the effort, when, if he had floated, a boat or other aid might have been obtained.

9. These instructions apply alike to all circumstances, whether as regards the roughest sea or smooth water.

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